The Canadian Entomologist

Vol. LXXXV Ottawa, Canada, October 1953 No. 10

Observations on Mosquitoes at Whitehorse, Yukon Territory (Culicidae: Diptera)[1]

By L. Colin Curtis[2]

Veterinary and Medical Entomology Section Laboratory of Entomology
Kamloops, British Columbia

Introduction

During the summers of 1949 and 1950, studies on the biology of mosquitoes were carried out at Whitehorse, Y.T.[3]

At Whitehorse, the principal area under study centred about the Royal Canadian Air Force Station. Some additional collections were made along the Northwest Staging Route, at Fort St. John and Fort Nelson, B.C., and Watson Lake, Y.T.

Whitehorse (altitude 2,000 ft.) lies at long. 135° west, lat. 60° 45′ north, at the head of navigation on the Yukon River. At this point, the river lies in a broad valley that runs approximately north and south. The terrain shows signs of much glaciation in the past, and the surrounding mountains, which rise to heights between 5,000 and 6,000 ft., are generally rounded in contour. The soil is gravelly, with some areas underlain by permafrost at a depth of three to four feet in summer. The dominant vegetation is a spruce-aspen association in the moist parts, with lodgepole pine occupying the drier areas. The timber is of small size, with little undergrowth. Swamp areas, which are not extensive, support a salix-ledum-carex association. The river itself occupies a gorge of varying width at a level about 300 ft. below that of the main valley, and is fed by numerous creeks, which drop steeply from the valley floor in well-defined channels, generally providing conditions better suited to the production of black flies than of mosquitoes. Fig. 1 is an outline map of the area, showing cage rearing sites.

Climate and Weather

The climate of the Yukon is variable, showing wide differences from place to place and from season to season. Meteorological records for Whitehorse do not go back far enough for valid averages, and though long-term figures are available for Carcross to the south, and Dawson City to the north, they are of little value in the present study. Records from 1941 to 1948 give Whitehorse an annual precipitation of 11 in., June and July being the wettest months. Figures for 1949 and 1950 were 10.17 in. and 8.87 in. respectively. Since the mosquito breeding areas are chiefly dependent upon melting snow for their moisture, it is interesting that the snowfall for the winter of 1948-9 was only 26.1 in., compared with an average of 47.1. for the preceding five years.

The mean January temperature is 4.6°F., and that for July is 56.3°F. The lowest recorded was –61.6° (1947) and the highest, 88.8° (1950).

For the two seasons under review, the following figures have been obtained from the daily weather sheets supplied by the Meteorological Office at White-

[1]Contribution No. 3039, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

[2]Agricultural Research Officer.

[3]Part of a program of research on biting flies conducted by the Division of Entomology, Science Service, Canada Department of Agriculture, on behalf of the Defence Research Board, and in co-operation with that organization and other agencies.

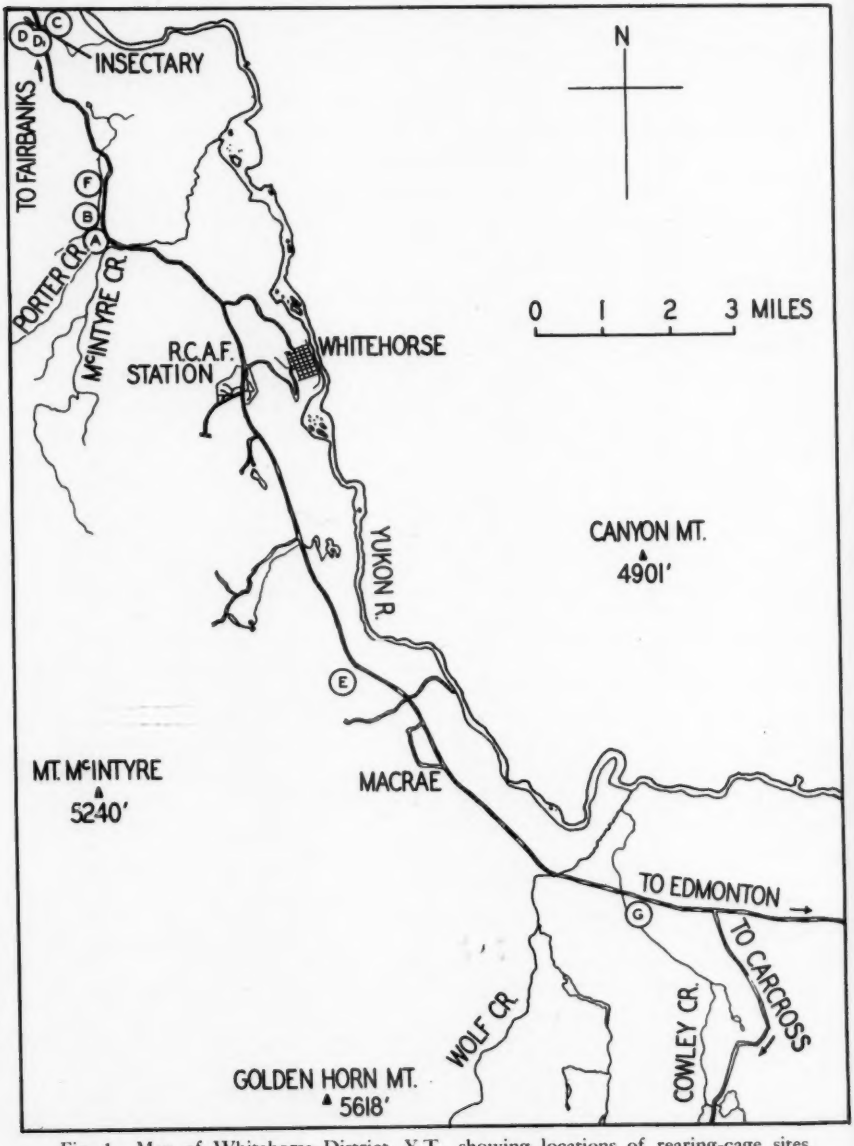


Fig. 1. Map of Whitehorse District, Y.T., showing locations of rearing-cage sites.

horse:—average temperature, whole season: 1949, 48.8°F; 1950, 56.5°F; average temperatures for periods in 1949 and 1950 respectively: May, 43.5°F, May 22-31, 44.6°F; June, 48.5°F and 59.1°F; July, 55.4°F and 53.7°F; August 1-23, 51.3°F; August, 55°F. The highest and lowest temperatures during the 1949 season were 81°F on July 9, and 19°F on May 1 and 7. In 1950 they were 89°F on June 17, and 32°F on May 23, 26, and 29.

The prevailing wind is south-southeast, and the season averages for 1949 and 1950 were 8.6 and 8.8 m.p.h. respectively, with monthly averages for the summer as follows:—May, 9.7; June, 9.5; July, 8.2; August, 7.9. The highest wind speeds recorded were 28 m.p.h. on May 11, 1949, and 40 m.p.h. on July 22, 1950.

Materials and Methods

Mass rearing of mosquitoes was carried out by the method used by Hocking *et al.* (1950) at Churchill. The cages were cylinders of copper wire screen, with brass frames, 24 in. high and 15 in. in diameter. The upper ends were closed by tight screen lids, and the lower ends were open. The bottom rims were each equipped with two perforated lugs, through which stout iron anchor-pins were passed into the substratum. These cages were placed in water about one foot deep, and stocked with larvae from the surrounding pool. On each subsequent visit the stock was replenished as long as the supply in the pool lasted.

Upon emerging, the adults rested on the sides of the cage, facing upward. At first they flew little, but crawled vertically up the wire, or if disturbed made short flights to higher positions.

The procedure for clearing the cage was as follows: a large collecting net was spread over the cage, and beneath it the lid was loosened and moved aside. The mosquitoes in the cage moved up into the net, which was then carried by its tip and suspended, mouth downward, from a nearby bush. The specimens were then picked off the inside of the net with a collecting jar and taken alive to the laboratory. The collecting jar was similar to that described by Mail (1934): a pint sealer fitted with a metal cone having an aperture of three quarters of an inch. The jar contained some crumpled one-inch strips of paper, which provided the specimens with a foothold. At the laboratory, a wad of chloroform-soaked cotton was applied to the aperture of the cone, and the insects were then pinned. By this method it was possible to obtain specimens that had suffered a minimum of damage to the scale pattern and were much superior to those taken in a killing bottle and transported in pill-boxes.

During 1950 an attempt was made to rear larvae individually in their native pools by means of floats. Each wooden float, two inches thick, was pierced with holes to accommodate 18 glass tubes 1¼ by three inches. The bottom of the float was covered with 32-by-32 nylon mesh. After pupation of the larvae, each tube was covered with gauze, held in place with rubber bands. This device was not satisfactory. Mortality was high, and the cast larval skins were heavily loaded with algal and fungous growth. This may have been due to the high temperature of the surface layer of water to which the larvae were confined, and to the restriction of their movements.

The most successful individual rearings were those carried out in the insectary. Here, collections of larvae were isolated in glass jars, each supplied with some vegetation from pools, renewed from time to time. No other food was provided. After pupation, the larval exuvium was placed in a numbered vial of alcohol-glycerin. Upon emergence, the adult was given a few hours to dry, then chloroformed and attached to the side of a No. 1 insect pin with shellac. The larval skins were immersed briefly in Cellosolve (ethylene glycol mono-ethyl ether), then mounted on slides with Euparal. Slides and pinned placed in micro-vials attached to the same pins as the corresponding adults for transfer to the Kamloops laboratory, where the skins were later mounted on slides. This method caused some damage to the delicate hairs and gills of the

specimens owing to extra handling and drying in the vials. Immediate mounting in the field laboratory was preferable.

Landing, biting, and sweeping counts were made at each station, as described by Hocking *et al.* (1950).

Cage Rearing Sites

The positions of the various stations are shown in Fig. 1. They were of necessity placed near the main highway, which runs along the benchland at heights varying from 200 to 400 ft. above the river.

Station A

A cage was established in a swamp alongside the Alaska Highway near Whitehorse, at Mile 919.5. This swamp results from seepage of water from Porter Creek, which borders it on the north side. The plant association is a typical sedge-willow one, with the willows widely scattered and averaging 10 ft. in height. The pool was about one foot deep at the start of the 1949 season; the bottom was composed of decaying vegetable matter, and until the end of July the anchor-pins of the cage were in contact with frozen substratum. When disturbed, the bottom gave off a strong smell of hydrogen sulphide. As the season advanced, the depth of water increased by several inches as a result of late rains. At no time was this pool shaded, and the water was subject to rapid changes of temperature, not uncommonly becoming warmer than the air above it. The lowest temperature observed was 46°F, and the highest, 68°F. The pH remained fairly constantly near 7.4. The oxygen content gradually declined through the season from 5 cc. per litre (NTP) to 1.5.

In 1949, the cage was maintained from May 11 to August 12. In 1950 it was established on May 27, but was destroyed by persons unknown after the observation on June 3. However, collections of larvae were made at this point during the remainder of the season and reared at the insectary. Table I shows the species represented. They include larvae taken from the swamp in both seasons and adults that emerged in the cage, or that were reared in the insectary.

Station B

This station was operated in 1949 only. It was situated about 50 yd. north of Station A and 10 yd. south of Porter Creek. Although this pool formed part of the same general swamp area as that at Station A, it had a consistently lower oxygen content throughout the season. This apparently had no bearing upon the species produced, as those found here accounted for about 95 per cent of the numbers taken at A. Water temperatures ranged from 43°F to 66°F and the pH was approximately 7.4 throughout the season.

Station C

Station C was in a pool at the southeast corner of a small lake east of the highway at Mile 923.5. The vegetation of the swamp was of the sedge-willow type, with scattered spruce and ledum on the drier hummocks. The pool was deeper than those at A and B, but the cage was placed in about one foot of water at the shelving end. It was in position from May 13 to August 5, 1949, but during the latter part of the season there were no larvae in the pool. The mosquitoes emerged in a mass, and there were no stragglers.

Section D

This was in a pool across the highway from Station C, on the margin of a wooded area. The pool had fairly steep sides rising about three feet above the water and sloping steeply below the surface to a considerable depth. The cage was placed on the edge of a moss-covered shelf of clay, in about 12 in. of water.

The surrounding trees were spruce about 30 ft. in height, and the ground in the immediate vicinity was almost bare of other vegetation, though carpeted with spruce needles. The pool was in moderate shade until late afternoon. A cage was placed here from May 21 to August 12, 1949. The peak of emergence occurred almost a month later than at Station C, and two weeks later than at Stations A and B. Temperatures ranged from 42°F to 59°F and the pH from 7.5 to 8.3. The oxygen content during the larval period ranged from 4.5 to 10 cc. per litre, but fell in August to 1.7.

Station D1

This cage was placed in a small, shallow pool a few yards east of Station D, and was in a more open position. The bottom was moss-covered, and shelved from a depth of a few inches to a little over a foot. The surrounding vegetation consisted of mosses, grasses, *Epilobium* spp., *Ribes* spp., and *Salix* spp. This was one of a group of similar pools, all somewhat obstructed with fallen logs and debris. The cage and float were maintained from May 26 to August 10, 1950. Water temperatures ranged from 44°F to 66°F, the pH from 7.6 to 8.1. The oxygen content at the start of the season was 4.3 cc. per litre.

Station E

This was situated in a small swamp resulting from a geological fault, and lay 100 yd. west of the highway at Mile 911.5, or five miles south of the air base. The pool lay at the foot of a small cliff that faced east. The plant association was sedge-willow-ledum, and the bottom of decaying sedge slanted from the eastern margin to a junction with the rock face on the west, where the maximum depth was about two feet. The surface was partly obstructed by dead branches from the lodgepole pines on the cliff above. The pool was in partial shade during the forenoon and completely shadowed by the rock face after 2 p.m. A cage was kept in position here from June 2 to July 26, 1949, and from May 28 to July 11, 1950. In both years, drying-up of the pool terminated observations. Temperatures ranged from 42°F to 56° in 1949 and from 43°F to 64°F in 1950. The pH ranged between 6.6 and 6.9, and the oxygen content from 4.2 to 5.5 cc. per litre.

Station F

A cage was established in a pool between Porter Creek and the highway at about Mile 920.5, after the destruction of the cage at Station A. The swamp was generally similar to that at Station A, and consisted of a sedge-willow association, with a considerable admixture of *Equisetum* spp. This pool was bordered on the east by a dense mass of *Salix* spp., 15 feet high, which screened the pool from the road and gave light shade in the early part of the day. The margin and bottom of the pool showed a growth of long grass and sedge, which gave it the appearance of a temporary rain pool. Yet the pool remained full through the season, and late rains inundated the whole surrounding area. This cage was in operation from June 5 to July 4, 1950, after which no more larvae appeared. Water temperatures varied from 50°F to 73°F, the pH remained close to 7.3, and a single oxygen determination gave a figure of 4 cc. per litre.

Station G

This pool was the only one in a completely wooded situation. It was formed by seepage from Cowley Creek, which crosses the highway at Mile 906, and lay about 50 yd. west of the road. The bottom sloped evenly on all sides to a depth of about three feet. The forest floor was partly bare with a scattering of spruce needles, and partly mossy. The timber was spruce about 40 ft. high,

with a scattered understory of willows. A clump of willows grew up from the bottom of the pool, suggesting that in some years the water level is lower than at any time in 1950. A cage was kept here from June 6 to August 31, 1950. Development of larvae began much later than at any other station, and continued after it had finished at all others. Water temperatures ranged from 44°F to 59°F; the pH remained at about 7.2.

Table I shows the species found at the cage sites, most of them having been reared in the cages and collected as adults.

TABLE I

Mosquito Species that Occurred at Cage Sites, Whitehorse, Y.T., 1949 and 1950

Species	Station							
	A	B	C	D	D1	E	F	G
Aedes communis (Deg.)	X	X	X	X	X	X	X	X
" *pionips* Dyar	X	X	X	X	X	X	X	X
" *punctor* (Kby.)	X	—	—	—	X	X	X	X
" *hexadontus* Dyar	X*	—	—	—	—	—	—	—
" *nearcticus* Dyar	—	—	—	X	X	X	X	—
" *pullatus* (Coq.)	X	X	—	—	X	X	X	X
" *excrucians* (Wlk.)	X	—	—	—	—	—	—	—
" *stimulans* (Wlk.)	X*	—	—	X	X*	—	—	—
" *fitchii* (F. & Y.)	X*	—	—	—	—	X*	X	—
" *canadensis* (Theo)	X	—	—	—	—	X*	X*	—
" *impiger* (Wlk.)	—	—	—	X	X	X	X	X
" *diantaeus* (H. D. & K.)	—	—	—	—	X	X	X	X
" *cataphylla* Dyar	—	—	—	—	—	X	X	X
" *campestris* D. & K.	—	—	—	—	—	X	—	—
Culiseta alaskaensis (Ludl.)	X	—	—	X	X	X	—	X
" *impatiens* (Wlk.)	—	—	—	—	—	—	—	X
" *incidens* (Thom.)	—	—	—	—	—	—	—	X
Culex apicalis (Adams)	X	—	—	X*	—	—	—	—
Mochlonyx culiciformis (Deg.)	X	X	X	X	—	X	—	X
Eucorethra underwoodii Undw.	—	—	—	—	—	X*	—	X

*Larvae were collected at the cage site, but no adults emerged in the cage.

The predominant species at each station were *Aedes communis* (Deg.), *A. pionips* Dyar, and *Culiseta alaskaensis* (Ludll.) The remainder were sparsely represented, sometimes by only a single specimen.

Water samples from all stations except F and G were tested for salinity at the University of Alberta, through the kindness of Professor B. Hocking, and it proved to be negligible.

Characteristics of the Mosquito Seasons

The 1949 season was apparently not typical of the region, probably owing to the unusually light snowfall of the previous winter and the consequently reduced amount of surface water in the spring. Landing, biting, and sweeping counts were totalled, and the resulting curve appears in Fig. 2, A. Fig. 2, B, gives the periods of emergence and relative abundance of the two most numerous species in the mass rearing cages. The second peak in the curve is largely due to the build-up of the *A. pionips* population.

A peculiarity of the 1950 season, as shown in Fig. 3, is that mosquitoes were active on the wing at all stations for about a week before there was any emer-

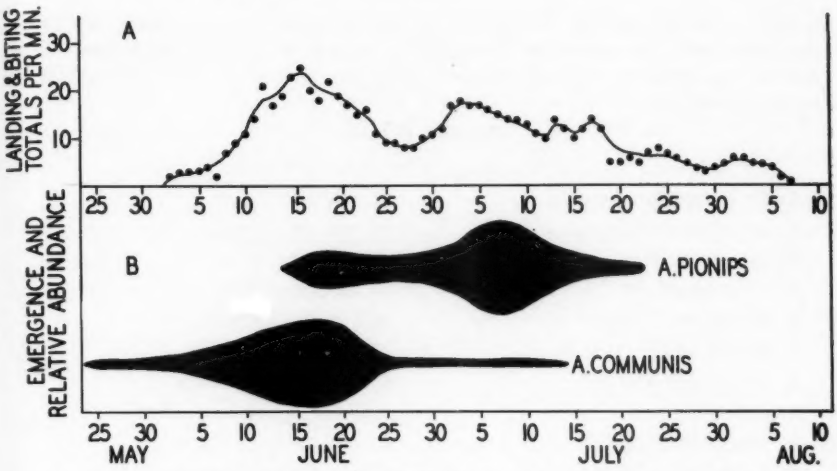


Fig. 2. A. Rates of mosquito attack at Whitehorse during summer of 1949. B. Periods of emergence of adults and relative numbers of the two principal species, 1949.

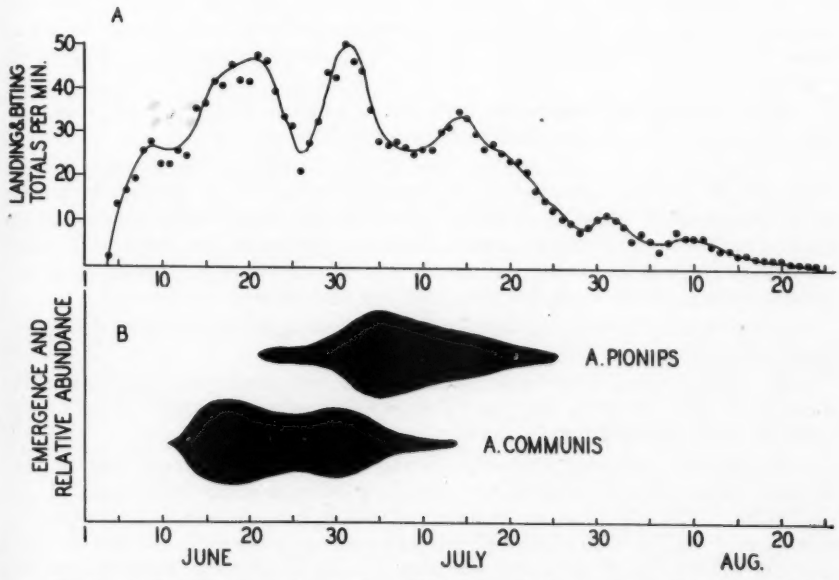


Fig. 3. A. Rates of mosquito attack at Whitehorse during summer of 1950. B. Periods of emergence of adults and relative numbers of the two principal species, 1950.

gence in the cages. It is difficult to account for this, as the cages were stocked when the bulk of the larvae were in second and third instars. It is possible that the first emergence occurred from shallow areas in the grassy swamps, whereas the cages were located in the deeper, central pools where the rise in temperature would be slower. The major dips in the curve are the result of cold and rainy

weather. As before, the first peak can be attributed to the emergence of *A. communis*, and the second to the addition of the *A. pionips* population. The other species present occurred in such small numbers as to have little effect on the total activity.

Species Present

The following species have been taken in the Whitehorse area:—

Aedes campestris D. & K.
A. canadensis (Theo.)
A. cataphylla Dyar
A. cinereus Meig.
A. communis (Deg.)
A. diantaeus H. D. & K.
A. excrucians (Wlk.)
A. fitchii (F. & Y.)
A. flavescens (Müll.)
A. hexodontus Dyar
A. impiger (Wlk.)
A. nearcticus Dyar
A. nigripes (Zett.)
A. pionips Dyar
A. pullatus (Coq.)
A. punctor (Kby.)
A. riparius D. & K.
A. stimulans (Wlk.)
Culex apicalis Adams
Culiseta alaskaensis (Ludl.)
C. impatiens (Wlk.)
C. incidens (Thom.)
Mochlonyx culiciformis (Deg.)
Eucorethra underwoodi Undw.

A. campestris was fairly common in open areas, and was strongly attracted attracted to man. In spite of the large numbers of adults encountered, no larvae were found in any collection, and only isolated specimens appeared in the rearing cages.

A. cataphylla was present in fairly large numbers and was most active in late afternoon. Swarming males were taken on June 10.

A. communis was the predominant species at all rearing stations and in random collections. Larvae of this species were the first to develop in nearly all situations; early instars were found when the first observations were made in mid-April, 1949. The adults outnumbered all other species in collections taken on man. The 24-hr. surveys indicated that *A. communis* is diurnal in habit, though most active in early morning and late afternoon.

A. fitchii was the most numerous of the banded-legged species, and was active chiefly in the hours of darkness and early morning.

A. nigripes was absent from the valley, but was found breeding in goodly numbers in pools near the summits of the neighbouring mountains, at or above 5,000 ft. climbers found this species very aggressive.

A. punctor was very numerous in the larval stages, and was one of the earliest species to hatch, its larvae occurring in association with those of *A. communis*. However, the adults emerged much later than the latter species, and formed only a minor part of the mosquito population in the area. This suggests a high larval or pupal mortality, possibly resulting from prolonged exposure to the attacks of predatory Chaoborinae, which were numerous in the area. The adults were persistent biters in the woods, and are readily attracted to man. They are the most active of the nocturnal mosquitoes in this area.

A. pionips was present with *A. communis* at all rearing stations, but hatched later and had a later peak of emergence. In spite of the presence of enormous numbers of larvae, this species was taken on man in much smaller numbers than *A. communis*, and was much less important as a pest. It does not appear to fly in darkness, but is most active immediately after dawn.

Other species collected in the area, but only in small numbers, were:—*A. excrucians, A. canadensis, A. impiger, A. diantaeus, A. nearcticus, A. pullatus,* and *A. stimulans.*

A. flavescens, A. cinereus, and *A. riparius* were rare at Whitehorse, each being represented by only one or two specimens in the two seasons' collecting. All three species were taken commonly at Fort Nelson and Fort St. John, in northeastern British Columbia east of the Rocky Mountains, in control assessments, and *A. riparius* was found breeding in large numbers at the latter point.

In the early spring, large numbers of overwintered adults of *Culiseta alaskaensis* were observed at Whitehorse, and newly emerged adults appeared in late summer. This species is not aggressive, and is considered of minor importance as a pest. A few specimens each of *C. incidens* and *C. impatiens* were also taken at Whitehorse. The latter species occurred much more commonly at Fort Nelson than at Whitehorse.

The only species of *Culex* found in the area was *C. apicalis,* of which a few specimens were taken in the sedge-willow swamps.

No species of *Anopheles* were found at Whitehorse, but a single adult of *A. earlei* Vargas was collected at Fort Nelson.

Larvae of *Mochlonyx culiciformis* occurred in all the deeper pools where the water was free of vegetation. These may spend the winter in larval form, as late instars were present in the spring before the appearance of *Aedes* larvae.

Emergence of Principal Species

Figs. 4 and 5 give, by sexes, the numbers and dates of adults of the two most important species, *Aedes communis* and *A. pionips,* that emerged in rearing cages in 1949 and 1950. The stations operated in 1949 were all situated in swamps of the open type, and in 1950 all but Station G, which was in a completely wooded situation, were of this type.

Both species concerned commenced emerging earlier in 1949 than in 1950, although development spread over a longer period in 1949. The earlier development in 1949 can probably be attributed to the abnormally light snowfall of the preceding winter and the absence of the cooling effect of deep snowbanks in the early spring. The longer development period in that year may be explained by the cool, cloudy weather that prevailed through much of the spring and early summer.

Culiseta alaskaensis appeared in numbers only at Station A, and this site was not used in 1950. Consequently, Fig. 6 refers to the 1949 season.

Predators

Wherever there was water more than a few inches deep, the larvae of *Mochlonyx culiciformis* were present and the pest species were almost completely absent. Well-developed larvae of this species were found before the hatching of the first *Aedes* larvae, and quickly eliminated the latter from the unobstructed portions of the breeding pools. However, the predatory larvae seemed not to pursue their prey among the sedges of the shallow margins, and it was in these areas that the *Aedes* larvae survived to maturity in great numbers.

Larvae of *Eucorethra* sp., presumably *underwoodi* Undw., were occasionally found, but were not present in sufficient numbers to be a significant factor in control of the pest species.

At the insectary swamp, near Station D, where an observer was present for the greater part of each day, several species of dragonflies and damselflies were

B & Z Library

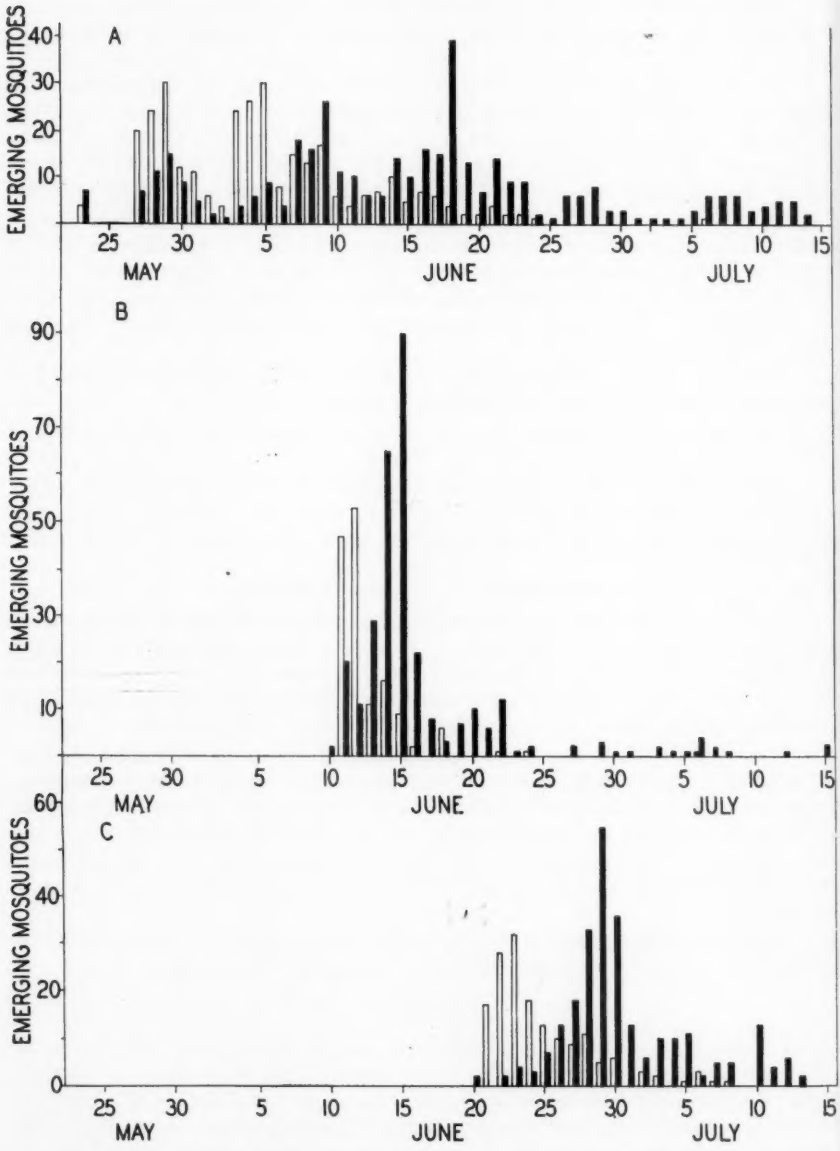


Fig. 4. Emergence of *A. communis* in cages at Whitehorse. A and B. Open stations in 1949 and 1950 respectively. C. Wooded station, 1950.

seen in large numbers. Shortly after their appearance, the population of mosquitoes in the immediate vicinity was sharply reduced. However, since the Odonata confine their hunting to the swamp areas, their value to the region in general is somewhat limited.

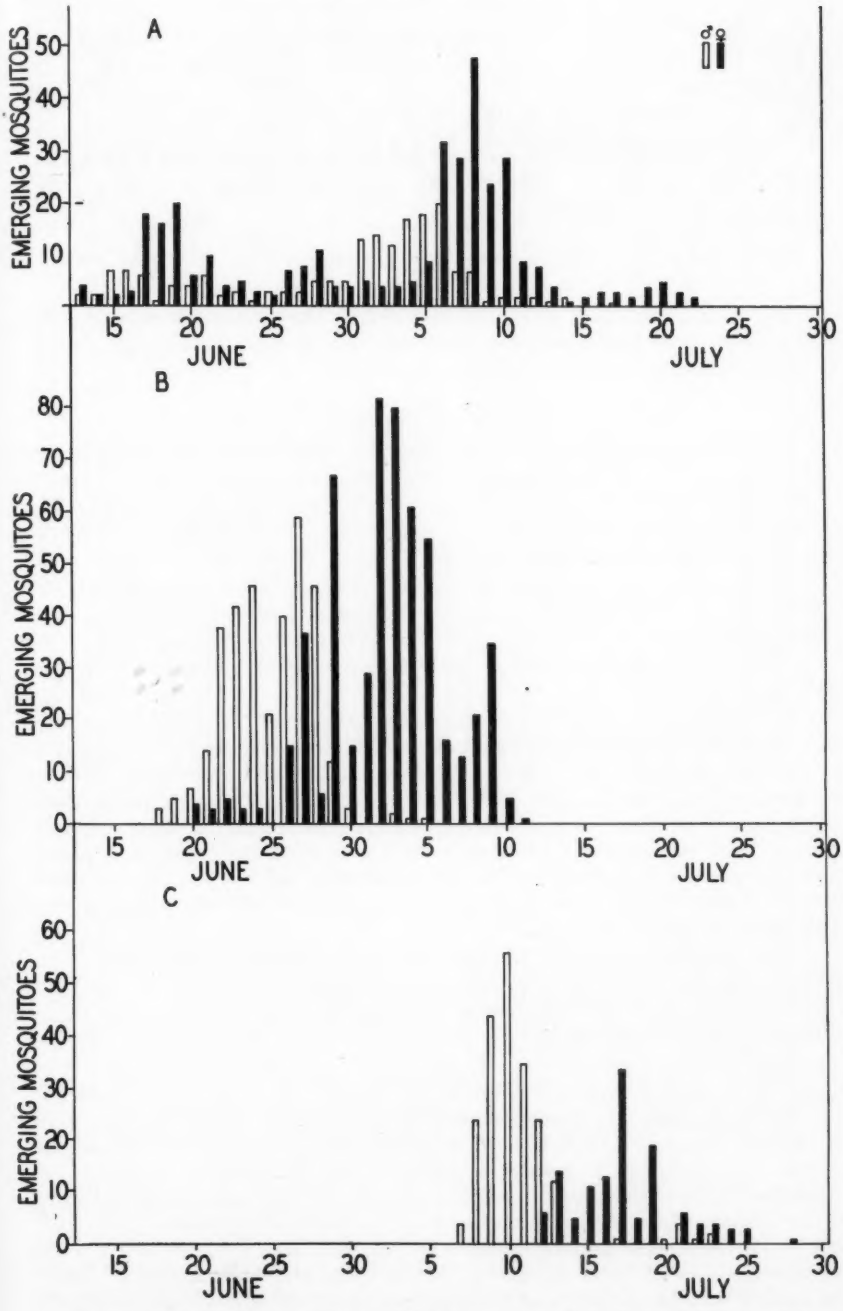


Fig. 5. Emergence of *A. pionips* at Whitehorse. A. and B. Open stations in 1949 and 1950 respectively. C. Wooded staation, 1950.

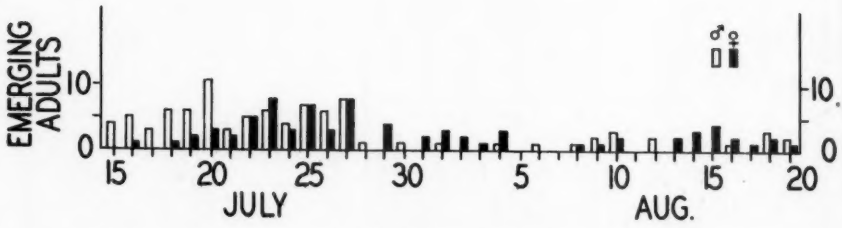


Fig. 6. Emergence of *Culiseta alaskaensis* in cages at Station A, Whitehorse, 1949.

Nighthawks and barn swallows were among the birds commonly observed, and were probably responsible for the destruction of many mosquitoes, although no stomach contents were examined to prove this.

24-hour Surveys

Four round-the-clock surveys of mosquito activity were made, one in 1949 and three in 1950. In 1949 the survey was delayed because of dull weather and much less than normal mosquito activity. It was made from 6 p.m. on July 27 to 5 p.m. on July 28, at Station E, in a comparatively open sedge-willow swamp near the Alaska Highway and about five miles south of Whitehorse.

During 1950, surveys were carried out at intervals of approximately two weeks, viz., on June 30-July 1, July 13-14, and August 3-4, at a point in the woods near Station D, seven miles north of Whitehorse. The site selected was on an abandoned logging road running through a forest of spruce averaging about 40 ft. in height.

At each hour of the survey the mosquito landing and biting rates were taken, and a record was made of temperature, humidity, wind speed and direction, cloud cover, and light intensity. The last factor was recorded by means of a Weston photo-electric exposure meter, held so as to receive light from directly above. After these observations, a number of specimens were taken for identification by picking them off observers' clothing with a collecting jar, killing and pinning them immediately; a standard number of specimens could not be taken each hour, because in the cold and dark of early morning three or four mosquitoes were all that could be found.

The data obtained from the four surveys are given in Figs. 7-10. These show the combined landing and biting rates, temperature, saturation deficiency, light intensity, cloud cover, period of total darkness, atmospheric pressure, and speed and direction of wind.

Activity of the Species

Inevitably, many of the specimens taken were badly rubbed and impossible to identify the species. Of those determined, the great majority were of four species: *A. communis, A. pionips, A. punctor, and A. impiger.* In Fig. 11, the numbers of each of these species taken in the four surveys are totalled and shown as a percentage of the total of all species for each hour. *A. communis* (Fig. 11,D) was by far the most important species attacking man, and was most active during daylight hours, with peaks during the forenoon and at evening twilight. This is the earliest species to emerge in the area, and therefore it is not surprising that, whereas it was the predominant species in the earlier surveys, it was insignificant in August, being replaced by *A. punctor* and *A. impiger.*

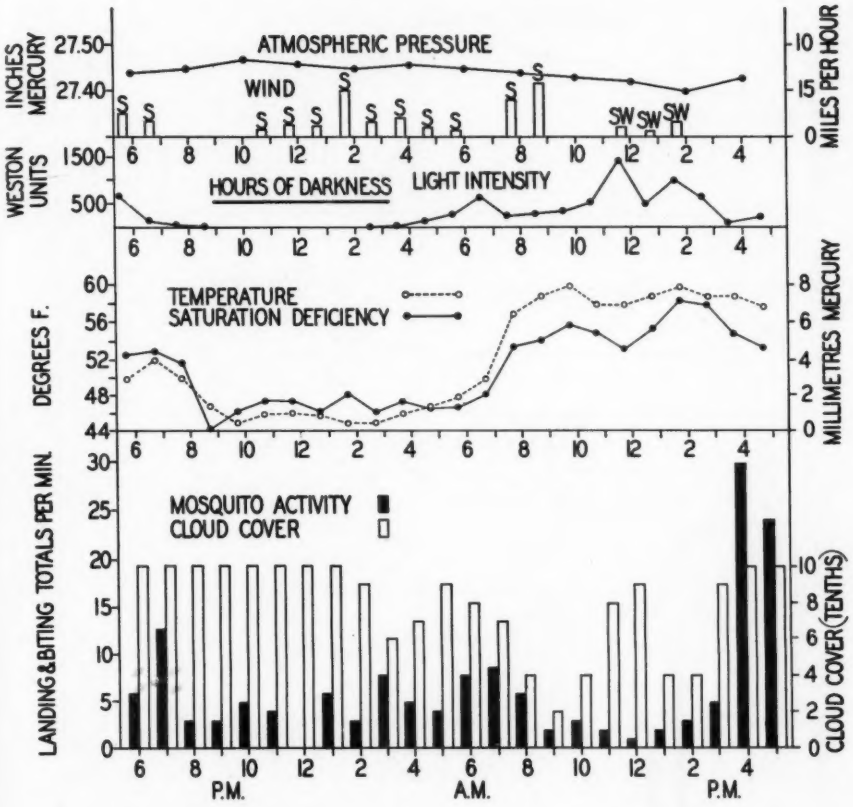


Fig. 7. Mosquito activity and meteorological data, 24-hr. survey, Whitehorse, July 27-28, 1949.

A. punctor (Fig. 11,C), present in small numbers in the rearing cages, was second only to *A. communis* in numbers attacking humans, and, in the survey of August 3, outnumbered that species. This is of interest because the fourth-instar larvae occur in the swamps at the same time and in approximately equal numbers. *A. punctor*, however, develops more slowly as indicated by its late peak, and suffers a higher rate of mortality, since the numbers of adults did not approach those of *A. communis* at its peak. *A. punctor* was the most actively nocturnal species, and small numbers continued to land in darkness when all others had suspended their activities because of low temperature.

A. impiger (Fig. 11,B) was captured in fair numbers, and proved to be of crepuscular rather than nocturnal habit.

A. pionips (Fig. 11,A), which, as reported above, emerged in the rearing cages in numbers as great as or greater than those of *A. communis*, was taken on humans only in the surveys on July 27, 1949, and June 30, 1950, and in small numbers. It appears to be only mildly attracted to the human host, and somewhat short-lived.

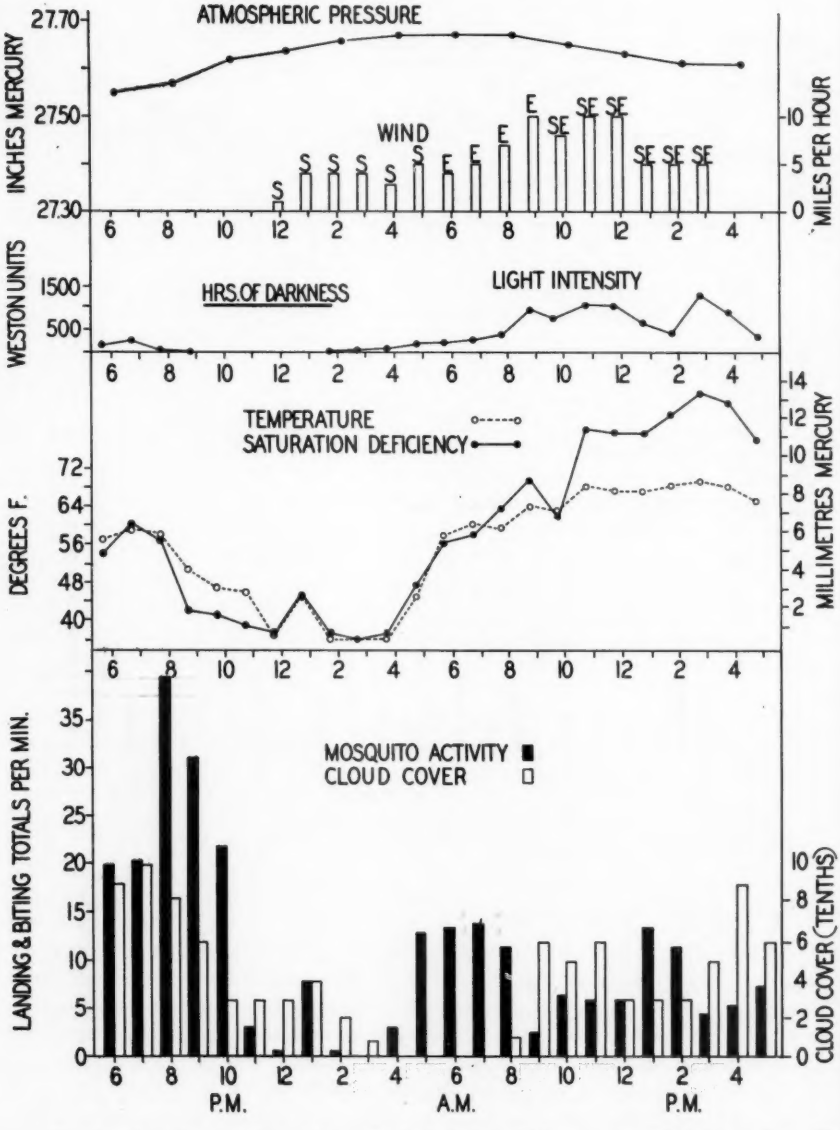


Fig. 8. Mosquito activity and meteorological data, 24-hr. survey, Whitehorse, June 30-July, 1950.

Meteorological Factors

Wind

During the greater part of all four surveys, air movement was absent or very slight. However, there were a few occasions when the wind speed rose to significant values. During the first survey (Fig. 7) the wind speed was below

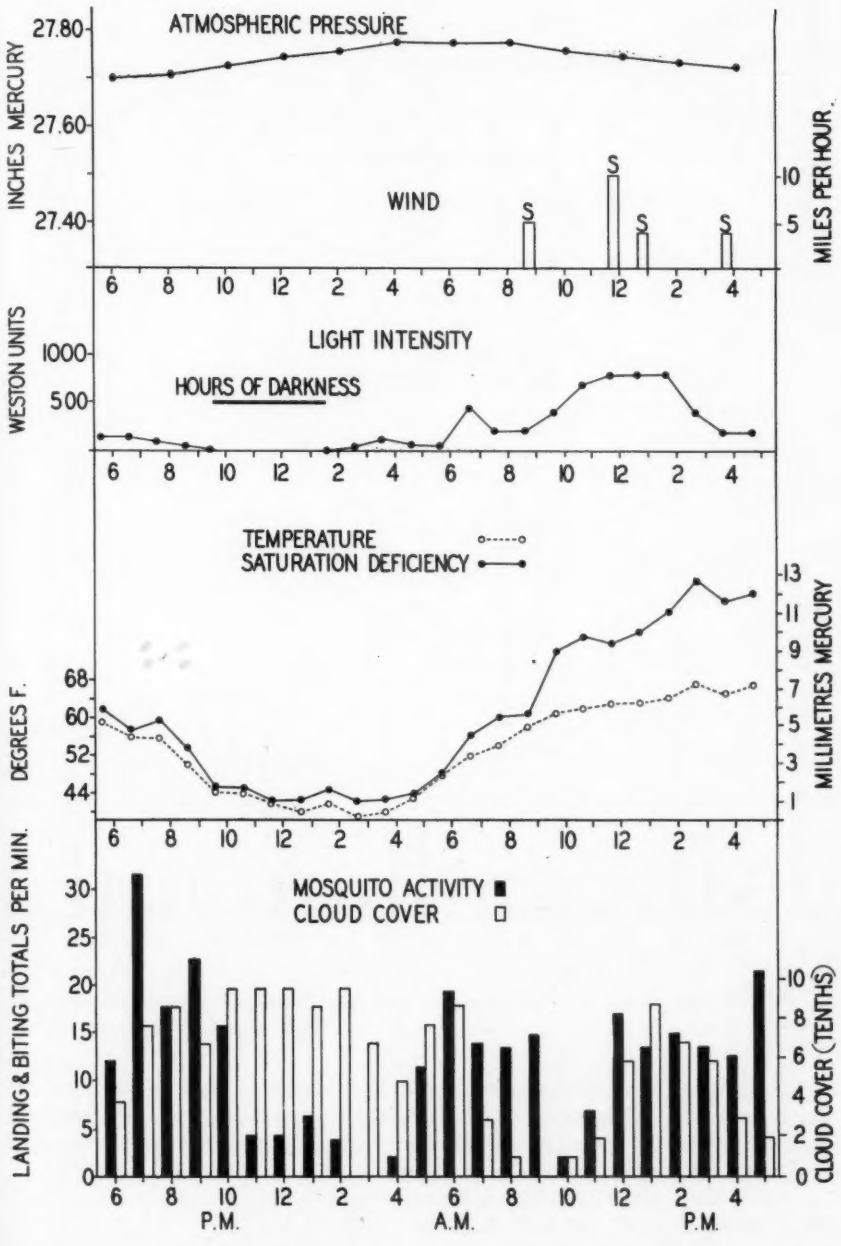


Fig. 9. Mosquito activity and meteorological data, 24-hr. survey, Whitehorse, July 13-14, 1950.

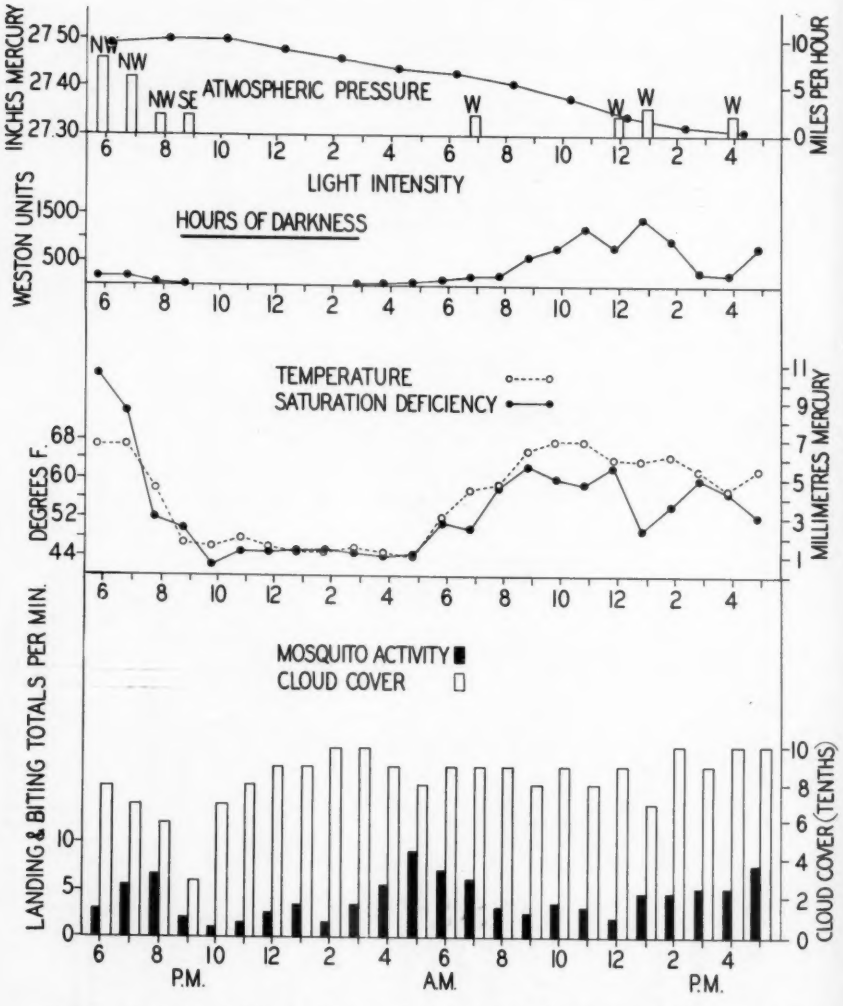


Fig. 10. Mosquito activity and meteorological data, 24-hr. survey, Whitehorse, August 3-4, 1950.

2 m.p.h. except when it rose at 4.8 m.p.h. at 2 a.m., 4 m.p.h. at 8 a.m., and 5.8 m.p.h. at 9 a.m. The rate of attack decreased on each occasion. The increases in wind speed were accompanied, however, by increases in saturation deficiency. A direct contradiction of the above appears in Fig. 8. For the greater part of the survey there was no wind at all, but at 9 a.m. a speed of 5 m.p.h. was recorded, and at noon, 10 m.p.h. for a short period, falling to 4 m.p.h. by 1 p.m. and zero at 4 p.m. On the latter occasion there was a sharp rise in the rate of attack that cannot be accounted for by any of the other factors recorded. It is possible that the speed recorded was indicative of stronger winds outside the shelter of the woods, and that the attackers at this time were seeking shelter among the trees.

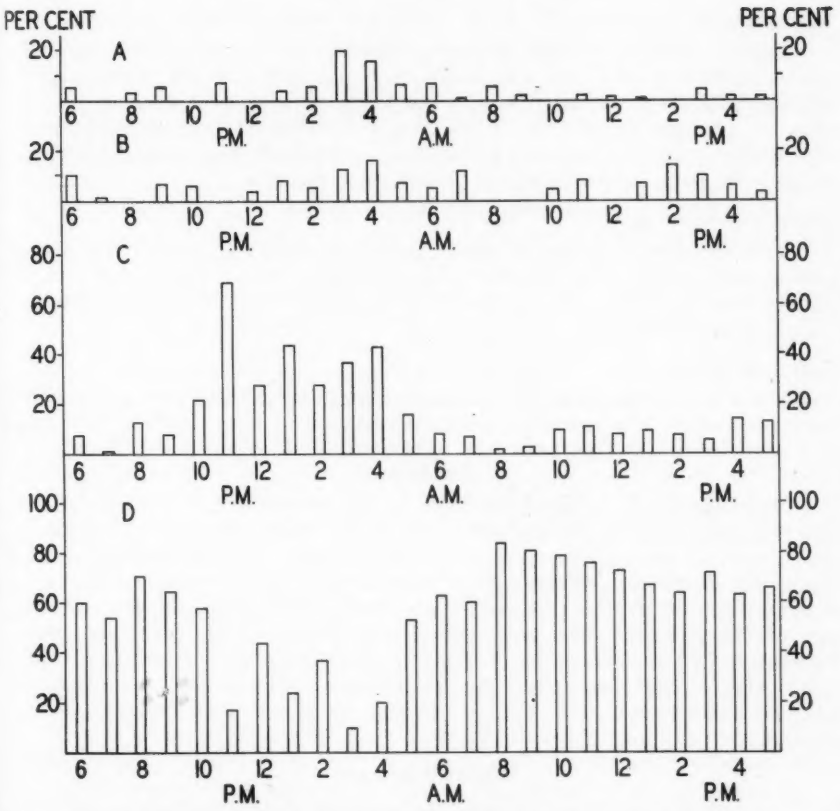


Fig. 11. Percentages of hourly captures contributed by the four most numerous species at Whitehorse. Totals of four 24-hr. surveys, 1949-50.

In Fig. 9 the wind speeds of 8 to 10 m.p.h. from 9 a.m. to noon appear to have been the controlling factors in the reduction of activity during that time.

During the final survey (Fig. 10) the only significant wind speed occurred at the start, when 8 m.p.h. was recorded. By 8 p.m. it had fallen to 2 m.p.h. and the rate of attack showed a fair rise, only to fall off again with the onset of darkness and low temperature.

Light

There are some apparent contradictions between the recorded light conditions and the cloud cover, an increase in cloud sometimes being accompanied by an increase in the incident light. This was found to be due to reflection from favourably placed masses of white cumulus, the light pouring down between the trees with an intensity exceeding that obtained from a clear sky.

On several occasions, an increase in activity occurred concurrently with a reduction in light intensity, when all other factors were relatively stable (Fig. 7, 4 p.m.; Fig. 9, 8 p.m. and 1 p.m.). However, no clear-cut example of the converse was obtained.

Temperature

During darkness, the limiting factor appeared to be temperature. Activity ceased entirely at 36°F and was negligible below 40°F. There was a striking increase in activity associated with a rise in temperature at 1 a.m. on July 14 (Fig. 9). A light breeze arose at this time, and continued, whereas temperature and mosquito activity had fallen by the time of the next observation. No upper limiting temperatures were reached during these surveys.

Atmospheric Pressure

The atmospheric pressures shown are those observed at the Whitehorse airfield, and were recorded at intervals of two hours from 6.30 p.m. for each of the observation periods. No relation was established between observed pressure and mosquito activity.

Saturation Deficiency

There is no evidence in any of these surveys to show that saturation deficiency consistently affects mosquito activity.

Summary

Observations on the mosquito fauna of the Whitehorse, Yukon Territory, area were made during the summers of 1949 and 1950. Data are presented on the occurrence and emergence of 17 species of *Aedes*, three of *Culiseta*, one of *Culex*, one of *Mochlonyx*, and one of *Eucorethra*. No *Anopheles* species were encountered at Whitehorse, although a single adult was collected at Fort Nelson, east of the Rockies. The predominant pest species in the area was *Aedes communis* (Deg.), followed by *A. punctor* (Kby.) and *A. pionips* Dyar. The last, though present in enormous numbers, appeared to be of only minor importance as a pest of man. The ecology and development of the various species are discussed.

Acknowledgments

The author is deeply appreciative of the co-operation and assistance received from the Commanding Officer and personnel of the Royal Canadian Air Force Station, Whitehorse, Y.T. Sincere thanks are due to Dr. C. R. Twinn, Head, and Mr. J. F. Sharp, Veterinary and Medical Entomology Unit, Ottawa, and Professor B. Hocking, University of Alberta, for their co-operation and advice in the field and laboratory. Thanks are also due to Messrs. K. Horie and R. H. Robertson of the Kamloops laboratory and to other members of the staff for their assistance in carrying out this study.

References

Hocking, B., W. R. Richards, and C. R. Twinn. 1950. Observations on the bionomics of some northern mosquito species (Culicidae: Diptera). *Canadian J. Res.*, D, 28: 58-80.

Mail, G. A. 1934. The mosquitoes of Montana. *Montana State Coll. Agr. Expt. Sta. Bull.* 288.

On the Identity and Status of *Eubaphe lamae* Freeman (Lepidoptera, Arctiidae)

By DOUGLAS C. FERGUSON
Nova Scotia Museum of Science, Halifax, N.S.

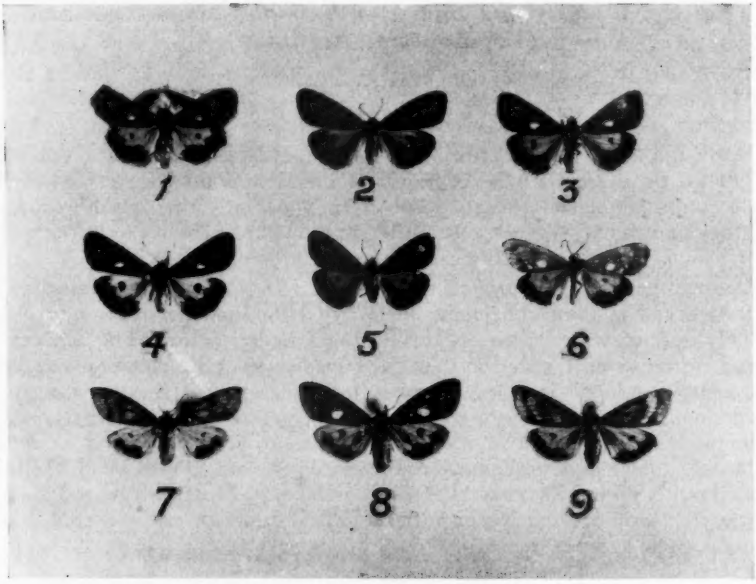
Although *lamae* was described as a species (Freeman, Can. Ent., Vol. 73, p. 123. 1941), there seems to be considerable doubt in some quarters whether it should continue to stand as such. Since I am apparently the only Lepidopterist with the opportunity to observe annually large numbers of this moth flying in its native haunts, it is felt that a few comments might be of interest.

As mentioned in the original description, *Eubaphe lamae* is closest to the species labelled in most collections *aurantiaca* Hbn., and the latter is probably the only species with which the males could be confused. The females are another matter since females of these two species, as well as *ferruginosa* Wlk., often run very close. Females of *lamae* are perhaps the most easily recognized, considering, in most specimens, the pale, orange-yellow shade of the secondaries as compared with the pink or rosy hue common to *ferruginosa* and *aurantiaca*. This would seem a good place to refer the reader to plate XIV of W. J. Holland's "Moth Book". Figure 19 looks like *lamae*, and figure 21 depicts what I refer to as *aurantiaca*, although the specimen that Holland figures is rather dark and lacks the usual discal spot on the secondaries.

Of 210 specimens of *lamae* examined in preparing this paper, about 46% of the males and 66% of the females bear the "well defined subcircular white spot just below the origin of Cu_2", although in the fresher specimens it is actually cream-colored or yellowish rather than white. As a means of characterizing the females of any one of the three species, these spots appear useless, as any specimen may or may not have them. The spots, however, do constitute a character that might help in separating males of *lamae* from those of its closest ally– *aurantiaca*, since the latter rarely, if ever, has them except in the females.

In *Eubaphe lamae*, the ground color of the primaries may be described as a shade of orange noticeably darker than the color of the secondaries, but typically this ground shade is all but completely obscured by a uniform deep brown suffusion, making the primaries appear very dark, in extreme cases very nearly as dark as the black border and discal spot of the secondaries. The deep brown suffusion occurs in varying degrees, and some females have very little of it. A similar situation may be seen in *aurantiaca*, but here the overlying brown shade is never as dark, nor does it obscure the ground color so uniformly.

In comparing the secondaries, two factors are important: the extent of the black border, and the shade of the ground color. We have in the collection males of *aurantiaca* with very narrow or broken black borders and even two Nova Scotian specimens, a male and a female, with totally immaculate secondaries. *Lamae* seemingly never has immaculate hind wings, and the males always have a broad unbroken black border, sometimes adjoining or even enveloping the discal spot. Most *aurantiaca* males have rather narrow black borders, but in this respect there do occur occasional variants not easily separated from *lamae*. The pale orange coloring of the hind wings in *lamae* is one of its most distinctive features, but even this is not absolutely constant. Of thirteen males and one female taken in 1952 in a bog at Pokemouche, Gloucester Co., N.B., five males show a decided tendency toward pink rather than orange hind wings. Nevertheless all the other *lamae*-like qualities of these specimens are, if anything, exaggerated. Presumably these represent a minor geographical strain.



Variation in *Eubaphe lamae*

1. *E. lamae*, holotype ♂. Baddeck, N.S., July 10, 1936. (*Courtesy Systematic Entomology, Ottawa*).
2. *E. lamae* ♂, Prospect Rd., Hfx. Co., N.S., July 21, 1952.
3. *E. lamae* ♂, same data.
4. *E. lamae* ♂, bred.
5. *E. lamae* ♂, with pink hind wings. Pokemouche, N.B., July 17, 1952.
6. *E. lamae* ♂, Sturgeon Bay, Door Co., Wis., July 8, 1933. (Wm. Sieker).
7. *E. lamae* ♀, bred.
8. *E. lamae* ♀, bred.
9. *E. lamae* ♀, Prospect Rd., Hfx. Co., N.S., July 21, 1952. Parent of bred specimens.

(Figures natural size)

In Nova Scotia, *lamae* and *aurantiaca* may occur within sight of each other in the same localities, yet they occupy quite different environmental niches. *Aurantiaca* flies most commonly in sandy pine barren areas or blueberry barrens, although it may occur almost anywhere in or near dry open woodland. *Lamae* is strictly a bog dweller, sharing its habitat with such species as *Plebeius argyrogomon empetri, Hemipachnobia monochromatea, Oligia minuscula, Syngrapha microgamma* and *Isturgia truncataria.* Whether *lamae* adheres to this sphagnous bog environment throughout its wide range is at present unknown.

There is another characteristic which, perhaps above all others, puts *lamae* in a class by itself. *It is a day flyer.* This, of course, is a common attribute of moths that inhabit bogs, but it points out how thoroughly this species is adapted to its environment. In bogs known to be teeming with *lamae*, I have sometimes had single individuals come to light, but it may be assumed that these were accidentally disturbed, since occasional butterflies and dragonflies also appear. *Aurantiaca* may be beaten out of low vegetation in the daytime and numbers may be collected in this way, but I doubt if it is a true dayflyer by nature. Unlike *lamae*, it comes regularly to light at night, often in considerable numbers.

In 1952 I reared on *Plantago* 54 offspring from two females of *lamae* taken in a bog near Halifax, and in spite of the unnatural treatment received, all of them looked like the parents. These did not hibernate as larvae, but pupated in the fall and emerged during October—a common response of *Eubaphe* to the artificial conditions of rearing.

The male genitalia are as useless for separating the species as those of *Olene*. The female genitalia have not been examined.

Considering the various peculiarities described, and bearing in mind that there is no known intergradation with other populations, I feel justified in regarding *lamae* as a distinct species, certainly as clearly defined a species as one might expect in this section of *Eubaphe*.

It has been suggested that *bimaculata* Saunders (Can. Ent., Vol. 2, p. 5. 1869) might be the same as *lamae*, but since the type was a female, now apparently lost, this name may never be satisfactorily tied down to any definite species. It would be a doubtful proposition even if the type were available for examination. The original description could apply to any one of the three species mentioned in this paper, since Saunders was seemingly unaware of the difficulties involved in the group with which he was dealing, a shortcoming I suppose quite understandable at that time.

Material Examined

Eubaphe lamae Frmn.
Nova Scotia (various localities): 162 ♂♂, 29 ♀♀, including a series from the type locality, Baddeck, Cape Breton Is.
New Brunswick (Pokemouche, Gloucester Co.): 13 ♂♂, 1 ♀
Maine (Passadumkeag Bog): 1 ♂
Wisconsin (Bailey's Harbour and Sturgeon Bay, Door Co.): 3 ♂♂
Manitoba (McCreary): 1 ♂
Period of flight: July 2-Aug. 20.
Eubaphe aurantiaca Hbn.
Nova Scotia (various localities): 31 ♂♂, 5 ♀♀
Massachusetts (Martha's Vineyard): 3 ♂♂
New Jersey (Orange Mts., Lakehurst): 17 ♂♂, 18 ♀♀
Illinois (Chicago, Waukegan): 3 ♂♂, 4 ♀♀
Indiana (Tremont, Hessville): 3 ♂♂, 1 ♀
Period of flight: July 4-Aug. 27.

A Study of the Prey, Enemies, and Habits of the Great-Golden Digger Wasp *Chlorion ichneumoneum* (L.)

By S. S. Ristich
Ohio State University

It is a paradox that a common wasp such as *Chlorion ichneumoneum* (L.) should be so unknown. Fernald (1907) states that the great-golden digger is found from South America to New England, and some parts of Canada, but until Frisch (1937) published his excellent paper only piecemeal accounts were written about its bionomics, prey, and parasites.

On the campus of Cornell University, two large colonies (about 50 wasps) have thrived for years. These conveniently located colonies offered a rich opportunity for a long range study.

General Information

During the summers of 1946-49 these two colonies were kept under intermittent observation. The largest of these two colonies of wasps occupied an area on deep cinder fill between the Veterinary building and an asphalt walk which faced east and west (Picture 1-4). The narrow strip along the walk was level but gave way to a bank facing southward toward the building. As the sun changed altitude during the day and declination during the season, the Veterinary building cast a shadow on different portions of the colony for varied periods of time. The influence of this shading on the distribution of nests will be discussed later. The smaller colony was located near White Hall on shallow cinder fill which is now overgrown by an unshaded lawn.

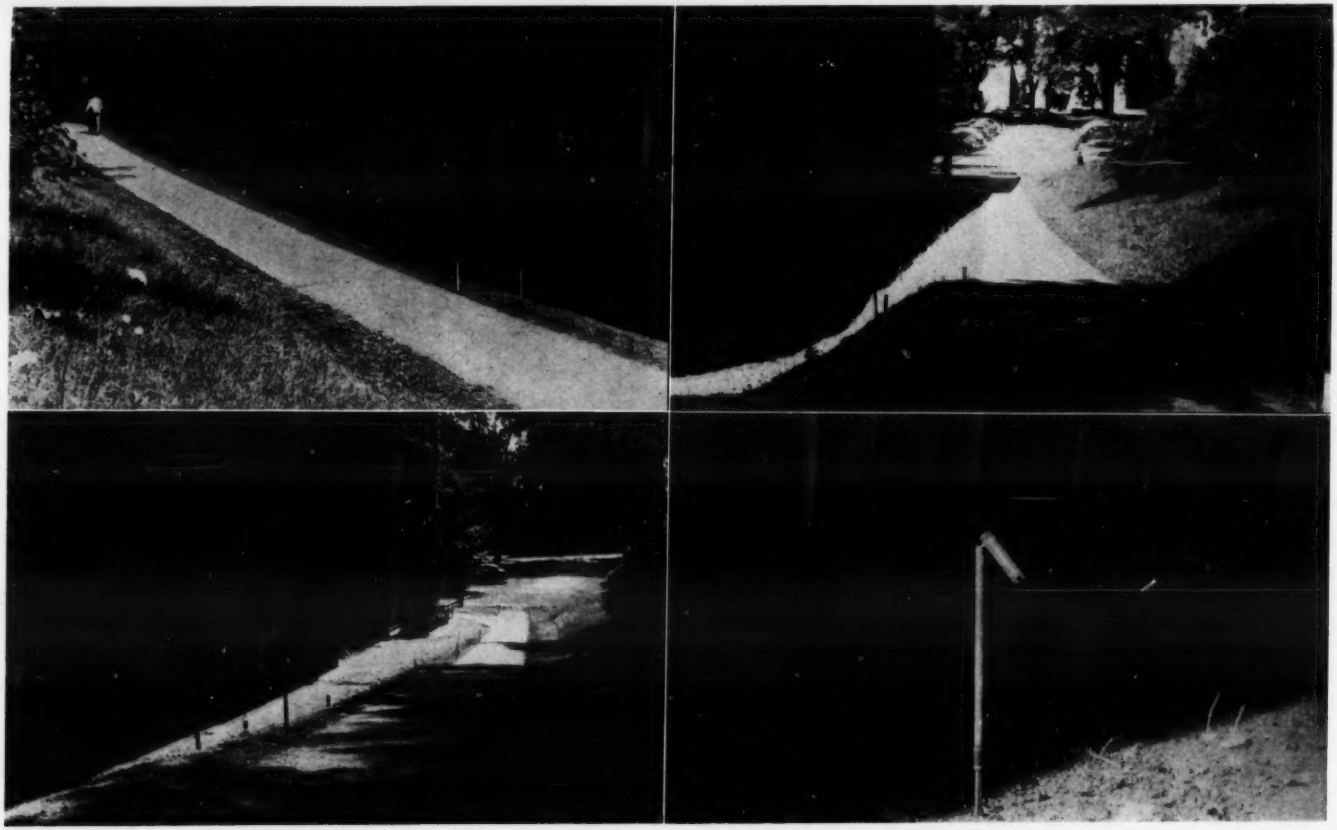
In these large colonies a system of marking had to be devised so the movements of individual wasps could be recorded. Each burrow was marked with a stake on which was written the date a wasp started to dig. Then each wasp was identified by contrasting spots of paint (i.e. scarlet, white, and yellow) which were dabbed on the head, thorax and wings. The fast drying Auto-Dupli-Color Touch Up* paint was applied by means of a thin wire while a wasp was busy excavating or bringing in a grasshopper. Wing painting requires a light touch since the paint will change the wing cambre and prevent flight.

Life History—Habits

The great-golden digger wasp, in New York, chews its way out of the ground about mid July. Mating must take place soon afterward because the females are digging and provisioning holes three days after their emergence. The elongate egg (5 mm by 1 mm) is placed on the ventral side of the prey perpendicular to the longitudinal axis, between the fore and mid coxae. Infrequently the egg may be placed beneath the labium. Only one egg, with rare exceptions, is left in a compartment on one of the grasshoppers regardless of the number of prey. The egg hatches in 2 to 3 days; the larvae remains in the chorion the first day while it feeds. Frisch (1937) states that the larval period lasts 6 to 9 days. No accurate information is available on the duration of the pupal period. In a normal summer only one generation and a partial second occur in Ithaca, but when the spring temperatures remain high, as in 1949, a definite second generation occurs.

Chlorion ichneumoneum hunts long horned grasshoppers. These grasshoppers, which are paralyzed afield, are clasped dorsum up by the wasp's legs and stabilized by the antennae which the wasp holds with her mandibles. The

*Dupli-Color Products Co. Inc., Chicago.



Pictures 1-4. Shows wasp colony along walk marked off by stakes. Top left: Entire area in sunshine. Top right: Western section in shade. Bottom left: East and middle section in semi-shade. Bottom right: Soil and air thermometer.

stupified prey is deposited at the entrance of the hole; the wasp then descends into the hole as if to inspect the subterranean chamber before she pulls the grasshopper in by the antennae.

Chlorion chews and digs to a depth of 5 to 12 inches. These holes with 1 to 3 compartments are provisioned by the females with 1 to 6 grasshoppers. Dirt from the surface, instead of the newly excavated dirt, is used to seal the provisioned chambers.

Males do not assist the females with the digging or the hunting. Each female partially closes the hole each evening and spends the night outdoors. The holes are reopened the following morning about 9 a.m. Each female excavates 3 to 5 holes at varying distances from the original hole. Most of the wasps terminated work about the first week in September. The new generation usually remains in the same area the following summer.

Prey

The wasps were watched throughout the summer as they brought back prey to their holes to be stored as food for the developing larvae. Table I and II illustrate the kind of prey the wasps captured and the relative number of each genus they captured. Chlorion seems to prefer the cone-headed grasshopper of the genus Neoconocephalus, *Neoconocephalus ensiger* being the most common Copiphorine caught. Three species of meadow grasshoppers *Conocephalus attenuatus*, *C. fasciatus*, and *C. brevipennis* were also caught in moderate numbers, mostly in mid August. The bush katydids *Scudderia texensis* and *S. pistillata*

TABLE I.

GENERA AND STAGE OF GRASSHOPPER FOUND IN THE HOLES OF *Chlorion ichneumoneum* AT DIFFERENT PARTS OF THE SEASON. ITHACA, N. Y.

Date Exhumed*	Neoconocephalus		Conocephalus		Scudderia		Amblycorypha	
	Adult	Nymph	Adult	Nymph	A	N	A	N
1946 Aug. 7–11	10	18[1]	1	0	0	0	0	0
1947 Aug. 26–Sept. 5	10	8[2]	2	0	0	0	0	0
1948—July 18–21	1	29[3]	0	0	0	4	0	0
1949—June 28–July 16	3	13	2	0	2	3	0	2
July 23—Aug. 20	4	12	18	7	1	2	2	0

Neoconocephalus ensiger (Harris)
Conocephalus attenuatus (Scudder)
C. fasciatus (De Geer)
C. brevipennis (Scudder)
Scudderia texensis (Saus. Pic.)
S. *pistillata* (Bruner)
Amblycorypha oblongifolia (De Geer)
Oecanthus n. nigricornis (F. Walker)

*8 to 10 hole samples
1 = about first 30 days
2 = " last 30 days
3 = " first 5 days

TABLE II

RECORD OF TYPE AND STAGE OF PREY CAPTURED BY *Chlorion ichneumoneum* IN DIFFERENT PARTS OF THE SEASON AT ITHACA, N.Y.

Period Taken	Neoconocephalus		Conocephalus		Scudderia		Amblycorypha		Oecanthus	
	Nymph	Adult	N	A	N	A	N	A	N	A
1947										
July 15–30	15	11	0	0	3	1	0	0	0	0
Aug. 1–30	8	17	1	0	0	0	0	0	0	0
Sept. 1–15	4	0	5	2	0	0	0	0	0	0
Total ♀ = 27 ♂ = 40										
1948										
July 15–30	33	4	1	0	2	1	0	0	0	0
Aug. 1–30	9	4	0	0	2	3	0	0	0	0
♀ = 31 ♂ = 28										
1949										
July 1–7	17	0	4	2	8	1	2	0	0	0
July 8–14	26	7	0	0	5	1	1	0	0	0
July 15–21	11	8	1	2	3	1	2	1	0	0
July 22–28	3	5	3	0	1	1	1	1	0	1
July 29–Aug. 4	0	2	1	0	1	1	0	0	0	0
Aug. 5–11	0	0	5	2	1	0	0	0	0	1
Aug. 12–19	0	0	6	6	0	0	0	0	0	1

were also captured occasionally. During the dry summer[1] of 1949, the wasps added two more species to the list of prey, these were *Amblycorypha oblongifolia* and *Oecanthus n. nigricornis.*

The Peckhams (1905), the Raus (1918), Reinhard (1927), and later Frisch (1937) have published some information about the species of grasshoppers caught for larval food. Both Frisch and Rau also have shown how the great-golden digger wasp collected mostly grasshoppers belonging to the genus Conocephalus and Neoconocephalus. Frisch demonstrated that the wasp shifts from one species of prey to another as the summer wanes. The data collected on the Cornell campus agrees closely with Frisch's observations. More nymphs of Neoconcephalus were caught earlier and more adults later in the summer as table II and figure 1 show. Before the season closed, however, the wasps had changed from coneheaded grasshoppers to meadow grasshoppers. Sixty-five percent of the early catch belonged to the genus Neoconocephalus, of which 5 percent were the pink variety, whereas Conocephalus comprised about 75 percent of the late summer's prey list. The wasps showed no sex preference. In 1947, 60 percent

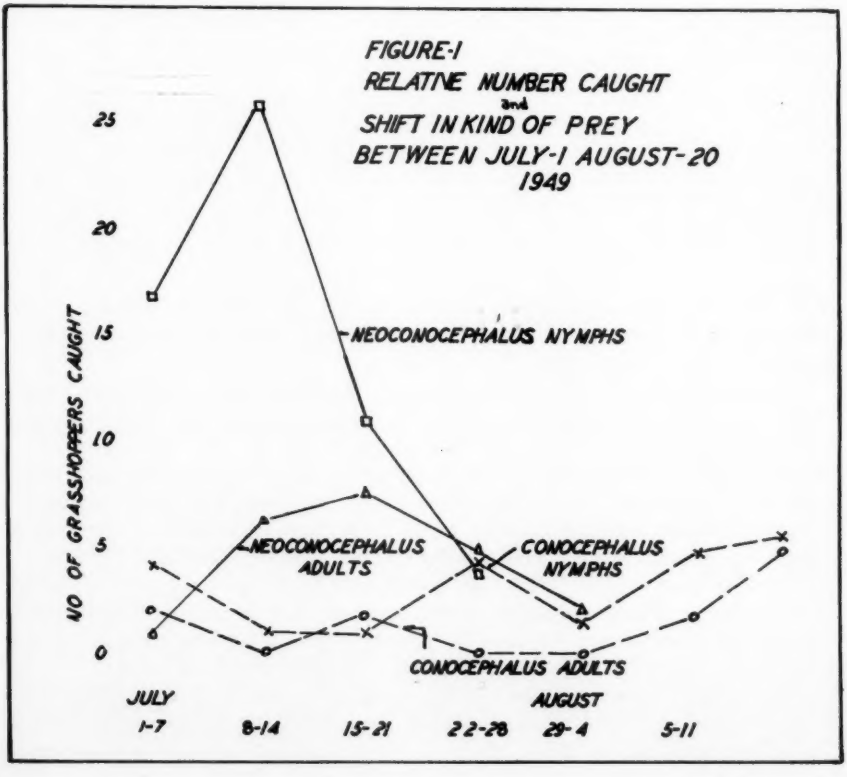
[1]The driest in 40 years.

of the grasshoppers caught were males, whereas in 1948, only 48 percent were males.

Enemies

The two colonies of wasps although only one-quarter of a mile apart were annoyed by different predators. At the Veterinary colony, the wasps were almost exterminated (1947) by robins and English sparrows who robbed the wasps of the grasshoppers. The robins would patrol the walks until a wasp arrived, whereupon the robin would attack the wasp causing it to drop the grasshopper. The English sparrows not only attacked along the walk, but also used the Veterinary building as an observation perch. From this vantage point, they could see more wasps homing. Many sparrows, with the first grasshopper still dangling from their beaks, would chase other wasps for a second meal. The birds did not bother the wasps in the White Hall colony.

The insect enemies in these two colonies were also different. The author realizes that the word enemies is a generalized term, but since a precise distinction can not be made between a predator and a parasite, we shall be partially justified to use the word enemies. Frisch (1937) and Allen (1926) have disagreed on the definition of a parasite and a predator. Allen does not consider the dipterous population as parasites since the maggots are not primary parasites even though their presence usually causes the death of the larvae. The mutillids are unques-



tionably parasites, but whether *Nysson plagiatus* is a parasite or a predator is not clear. Hamm (1930) shows that many species of Nysson associated with certain species of the genus Gorytes are parasitic. Probably the larvae are not primary parasites, but at least the Nysson larvae is a predator since its presence results in the death of the host larvae. Bequaert (1933) has cited evidence to show that *Nysson fidelis* (Cress.) lays eggs on leafhoppers collected by Gorytes. Pate (1938) says species of the genus Nysson are inquilines or cleptobionts, but surmises that they could be parasites. Dipterous larvae are predators and scavengers since they consume the grasshoppers and frequently the wasp larvae. *Muscina stabulans* is usually a scavenger, but the author (1950) has found many larvae of this muscoid fly and its relative *Muscina assimilis* (Fall.) devouring maggots of *Hylemya cilicrura* (Rond.) in laboratory cultures. *Metopia leucocephala* and *M. campestris* were common enough so the maggots could be reared in the laboratory after the contents of the wasp burrows were dug up. Frequently these maggots consumed the larvae (2 to 3 days old) of the wasp as well as the provender. The swift flying diptera *Senotainia trilineata* was very common at the White Hall colony, yet the fly was seemingly absent in the other colony. This apparent absence from the Veterinary colony does not exclude its presence, for the fly is a harasser, and does not crawl into the burrows.[2] The fly was reared from puparia collected in holes at the White Hall colony, but the dozen or so samples from the Veterinary colony did not contain puparia of *Senotainia.* Only one specimen of *Euaraba tergata* was caught, so its relationship in this colony is unknown. LaRivers (1944) has shown that this fly is a common parasite in the burrows of *Chlorion laeviventris* (Cress.), the wasp which is an effective predator on the Mormon cricket.

Nysson plagiatus is a wasp conspicuously colored with yellow and chestnut. It is a slow moving wasp which remained within the Chlorion colony for many hours. It was common at the White Hall colony until the over zealous summer students begin collecting this colorful wasp. At the other colony, only one specimen of this wasp was seen in four summers. Table III summarizes the parasite–predator–scavenger data collected for three summers.

Certainly, unchecked, the robins and sparrows would weaken or eliminate a colony. Insect enemies undoubtedly prevent rapid expansion of this species. At the Veterinary colony, about 20 per cent of the nests were parasitized; at the White Hall colony, 35 per cent. Many of the compartments harbored from 2 to 24 parasites each. It does not follow, however, that no larvae survived in holes where parasites or scavengers were present.

Chlorion ichneumoneum digs many holes which she abandons. These holes are usually taken over by other hymenoptera like *Lyroda subita* (Say), the huntress of *Nemobius.* This cricket hunting species was very common at the Veterinary colony and absent at the White Hall colony.

Two Megachilids, *Megachila texana* (Cr.) and *M. latimanus* (Say) had nests in the Veterinary colony. These were not found at the White Hall colony. *Philanthus* sp. was present in both colonies. The parasitic bee *Coelioxys octodentata* (Say) was also caught in the Veterinary colony.

Habits of the Enemies

The behavior of insects makes a fascinating study and though frequently complex, may take on meaning when more information has been gathered and evaluated. The habits of the insect enemies of the golden-digger wasp are varied.

2Frisch claims it does; Allen disagrees. My observations of this fly in these colonies and in colonies of *Microbembix monodonta* (Say) agree with Allen's.

TABLE III

ENEMIES OF *Chlorion ichneumoneum* (L.) IN TWO COLONIES ¼ MILE APART, ITHACA, N.Y., 1947–49

ENEMIES	OCCURRENCE IN	
	VETERINARY COLONY	WHITE HALL COLONY
Mutillidae		
Pseudomethoca frigida (Sm.)[1]	Common	Rare
Timulla v. vagans (F.)	Common	Rare
Sphecidae		
Nysson plagiatus (Cr.)[2]	Rare	Common
Nysson lateralis (Pack.)[3]	Rare	?
Megachilidae		
Coelioxys octodentata (Say)[2]	Rare	Rare
Metopiidae		
Metopia leucocephala (Rossi)*	Common	Common
Metopia campestris (Fall.)*	Prob. Common	Common
Senotainia trilineata (V.d.W.)*	?	Common
Euaraba tergata (Coq.)[2]	?	Rare
Muscina stabulans (Fall.)*	14 puparia in one Hole	?
Larvaevoridae		
Compsilura concinnata (Mg.)[2]	None	None
Robins	Common	Rare
English Sparrows	Common	None
Man	Common	Rare

1. Caught in the burrows.
2. Caught in the colonies.
3. Probable parasite of one of the species of Megachila present in the wasp colony.
* Reared from larvae.

Nysson plagiatus is a slow moving wasp which stays within the colony of the digger wasps day after day, crawling into one burrow after another. The host wasps do not seem to resent its presence. The mutillids on the other hand cause a great deal of irritation to the host wasps. *Metopia leucocephala* and *M. campestris* sometime wait for as much as 30 minutes on the hole marker for Chlorion to depart so they can enter and larviposit. *S. trilineata* belonging to the same group, acts in a different manner. According to Allen (1926) this species does not crawl into the burrows to larviposit, but is stimulated to larviposit only in the presence of a digger wasp with a grasshopper.

The actions of *S. trilineata* were observed in the White Hall colony and confirmed Allen's observations completely. Here a digger wasp would fly low with a meadow grasshopper to attempt a landing. She did not land at once but flew about the area first. Finally she landed, dropped the grasshopper, but turned quickly, grabbed the grasshopper, and flew to the trees. She soon returned to make another attempt and another, until she had returned nine times without being able to bury the grasshopper. The cause of all this difficulty were three flies of the genus *S. trilineata* who would fly at her each time she attempted to land and would pursue her as she flew away with her load.

Emergence

Ground temperatures govern the date of emergence. When spring and early summer temperatures are near the average, many of the wasps emerge about the third week in July, year after year. When the spring temperatures remain above the monthly mean (as in 1949) the wasps will emerge as much as three weeks earlier.

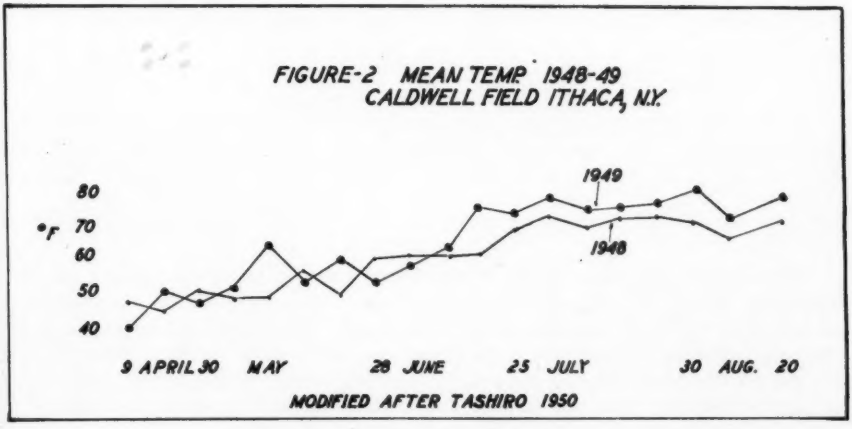
TABLE IV

DATE OF EMERGENCE AND APPROXIMATE CESSATION OF WORK.

YEAR	DATE EMERGENCE	DATE MOST HUNTING ENDED
1946	July 15	Sept. 3–7
1947	16	7–10
1948	10	5–10
1949	June 21*	Aug. 27–30
1950	July 18	

*In Maryland this is the average emergence date, according to Frisch.

Below is a graph of air temperatures for the spring and summer of 1948-49. Two periods of hot weather prevailed May 1 to 14 and again from mid June to mid August. These high temperatures are unquestionably responsible for the early emergence and the second generation.



Sunlight and Population Density

The wasps seemed to favor some sectors in the area more than others. The ground cover and substrate on the southside of the Veterinary colony walk, were not different enough to cause the wasps to shift to one sector. The north side of this walk did, however, have a different microclimate. The ground and substrate were a mixture of clay and rock fill. Most of the area was over grown by orchard grass *Dactylis glomerata* L. Not one hole was dug here, although a few wasps probed for a nest site. Frisch (1937) and Fernald (1945) reported that the wasps they observed, dug holes in places with a southern exposure. The Veterinary colony was ideally located for study of sunlight and its influence on population densities. Since the long portion of the colony

extended east and west, it was divided into three equal sectors. The approximate soil temperatures were taken at a depth of four inches with a plunger type of soil thermometer (Picture 4). The hours of sunlight per sector were estimated about every other day at three different periods. This was a simple task since the building which was south of the colony cast a shadow on different parts of the colony at different times. (Pictures 1-3). The western sector remained progressively longer in the shadow as the sun's declination changed. Although the soil temperatures may not be the significant factor influencing populations in this microclimate, they may be important. Chapman (1931), however, showed that soil temperatures governed the length of time *Bembex pruinosa* Fab. remained in the area or the time she reported for work.

TABLE V.

APPROXIMATE HOURS OF SUNSHINE PER DAY IN EACH AREA THROUGHOUT THE SEASON — 1949.

A (WEST)	B (MIDDLE)	C (EAST)
5½	8	8

TABLE VI.

AVERAGE SOIL TEMPERATURES (°F) AT 4 INCHES. JULY 20 — SEPT. 5

A	B	C
1946		
64	71	71
1948		
71	75	77

The wasps dug fewer holes in the western sector probably because of the increasing hours of shading and cooler soils. The site of the colony was undoubtedly selected because of the cinder fill. Of course the substrate will partially influence a wasp when she is probing for a place to dig. Many holes are started but never finished (as was the case on the north side of the walk). It has been suggested that the larger bank in area Bank C (even though surface area was approximately equal in all sectors) attracted the wasps.

Site Selection and Temperament

A question frequently asked is, "where do the females go after they provision one hole?" The painted wasps offered the solution. Most wasps started a new hole soon after they closed the old hole, and these holes were usually in the same sector, as the figures show though a few wasps started new holes as much as fifty feet from the original burrow.

The wasps return year after year to the same colony. Fernald (1945) has made intermittent observations of a colony in Massachusetts for twenty-five years and at Ithaca a new generation has returned to the same site on the Cornell campus for at least 12 years. Thus these permanent sites have afforded an excellent

TABLE VII.

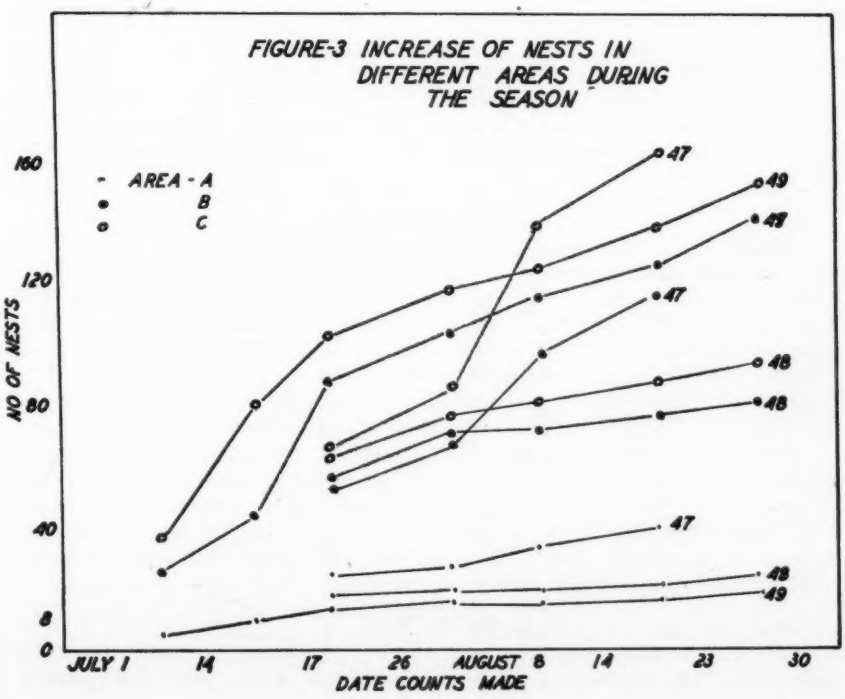
DISTANCE FEMALES TRAVELLED TO DIG A NEW HOLE.

Distance Travelled (feet)	No. Observed	No. Observed
	1947	1948
1–5	22	17
6–15	11	5
16–25	6	4
26.	7	4

opportunity for a long range study of habits and temperament. Even though the wasps are gregarious they maintain their individuality in many ways such as warning a neighbor she is in the wrong hole, or fighting a high-jacking neighbor. At the White Hall colony, high-jacking was a common occurrence, at the Veterinary colony, infrequent. Many females had to fight off two or three attackers before they reached their holes with the grasshopper. These battle royals, a result of the stealing, were so frequent, that they provided fine screen material for a Kodachrome movie.[3]

Chlorion does not take the grasshopper directly into the hole. Instead she places it before the entrance and presumably descends to inspect the subterranean cell. A fine teleological assumption, but most females descend as many as ten times if you upset the sequence of events by turning the grasshopper while they are

[3]Available from the Visual Aids Department, Robert's Hall, Cornell University.



inspecting. Most females evidently do not have the power to cope with a sudden change in their pattern of life. Abbott (1931), however, shows that some females can be conditioned after they have been fooled three or four times by the experimenter. Some females take the grasshopper into the hole directly—precluding the inspection. The author has observed that some tormented females will drag the grasshopper in backwards instead of coming out to rearrange the prey. They succeed, if the grasshopper is a young nymph, but the wasp fails to drag an adult into a hole backwards. The saltatory hind legs are too large.

A female usually digs more than one compartment. More cells mean less holes to dig and consequently less work to perform, but this labor saving scheme is nullified by a foolish procedure. When a wasp seals a cell, she ascends to kick back old dirt instead of using the dirt she chews out of the new cell.

The Raus and Peckhams state a wasp can dig a hole in two hours. This rate of excavating is possible in sand or cinder fill. Some females digging in hard ground, require two to three days to complete a hole. Very few wasps finished holes at the White Hall colony in less than two days. Many holes were abandoned because the substrate was too hard. Most holes in this colony ranged from 5 to 7 inches in depth, whereas at the Veterinary colony, where the cinder fill was deep, holes were 8 to 12 inches deep. Each evening, as Frisch states, the wasps partially fill their holes. Apparently this dirt prevents nocturnal raids by ground beetles, but this assumption may be incorrect.

The female seals the old hole before she starts another by kicking the dirt "dog-fashion" into the hole; then descending to pack the dirt with her head, vibrating her wings while she works. There are many variations to this procedure. Some females kick the dirt near the entrance, enter the hole and scoop the dirt into the hole with the fossorial front legs. Others chew away the dirt near the entrance before they use the previously excavated soil. Most females fill the hole completely; others fill within one inch of the surface. Where some select only fine dirt for refilling, others mix pebbles and dirt. The wasps differ even in the final camouflaging touches. One type of wasp (the Indifferent) fills the hole; makes a few passes at levelling; and then leaves. The other type (the Meticulous) will smooth and resmooth the surface and some return three times to retouch the camouflage.

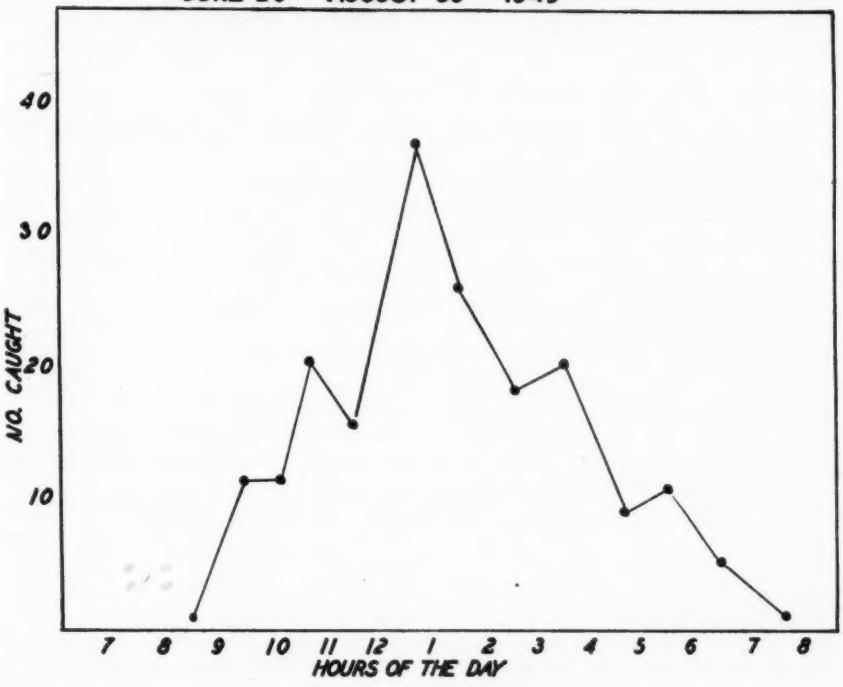
Homing Instinct

Many pages have been written about the wasp's homing instinct. She deserves these praises for even camouflaging of the entrance or the area rarely fools a wasp completely. But a wasp that loses speed while carrying an adult cone-headed grasshopper, has a difficult search for the hole. If she lands at a distance from the hole, the wasp must walk and still conveniently hold the grasshopper. For ground manoeuvring, the wasp holds its prey by the antennae. The question is how does the female gather the thin antennae in her coarse mandibles? One wasp was observed trying to take hold of a grasshopper. She would stroke its head along the frons toward the vertex over and over again. A closer inspection indicated that the antennae of the grasshopper were missing and that Chlorion was trying to gather these missing antennae in her mandibles. After many more futile caresses, she grasped the grasshopper leg but this hold was not suitable so she tried a wing. Her struggles were interrupted when the cone headed grasshopper was taken away to be preserved.

On the Wing

Many conjectures have been made about the distance these wasps travel for their prey. The marking of wasps, it was hoped, would settle this question.

FIGURE-4
OBSERVED NUMBER OF GRASSHOPPERS CAUGHT BETWEEN CERTAIN HOURS DURING THE SEASON JUNE 26 AUGUST 30 1949



The experiment was almost a failure since only two wasps were retrieved in four years. Both specimens were caught about 1½ miles from the colony.

Work Rhythm

Most insects have an activity pattern; some are nocturnal, some crepuscular, and most others diurnal. These wasps as the Fig. 4 shows, did their hunting between the hours 9 a.m. and 6 p.m. with the peak occurring between 11 a.m. and 3 p.m. Frisch's colony of wasps in Maryland ceased work about 3 p.m. Although he did not record surface temperatures, it could probably be proved that high surface temperatures as well as high ground temperatures cause a cessation of activity. At the White Hall colony, which was exposed to the sun constantly (except from about 5 p.m. to 7 p.m.), the hunting was almost halted during the late afternoon hours. Hunting was resumed about 5 p.m. Whereas, at the Veterinary colony, which the graph represents, surface temperatures were moderated by the intermittent shading, and the wasps continued hunting. Some females re-opened holes at 8 a.m. and others dug until 8 p.m.

No chapter is complete without an evaluation of insect behavior. Incomplete data, the author realizes, provoke prolonged arguments. For this reason, the scattered observations made in these two colonies will be withheld until more extensive records have been gathered and evaluated.

Acknowledgments

I am indebted to Dr. Charles Palm for his guidance, to Dr. J. A. G. Rehn, to the staff of the United States National Museum for identifying the specimens, and to Dr. F. Butt for his patient and tireless criticism. The pictures and graphs were made possible by a grant from the Grace H. Griswold Fund, at Cornell University.

References

Allen, H. W. 1926. North American species of two-winged flies, belonging to the tribe Miltogrammini. *Proc. U.S. Nat. Mus.* 68: 1-106 (Excellent paper on dipterous parasites of fossorial wasps.)

Abbott, R. L. 1931. Instinct and Intelligence in the Great-Golden Digger. *Iowa Acad. Sci. Proc.* 38: 255-258. (Brief discussion of the intelligence of a few wasps.)

Bequaert, J. 1930. Nesting habits of Isodontia, a subgenus of Chlorion. *Brooklyn Ent. Soc. Bul.* 25: 112-123.

1933. The nesting habits of Paranysson, an African genus of Fossorial Wasps. *Ent. News.* 44: 36-39.

Chapman, R. N. 1931. Communities of the Sand Dune. (In Animal Ecology). McGraw Hill Book Co., New York.

Davis, W. T. 1911. Miscellaneous notes on collecting in Georgia. *Jour. N.Y. Ent. Soc.* 19: 218. (Mentions prey taken from one nest).

Fernald, H. T. 1945. A Colony of Solitary Wasps (Hymenoptera: Chlorionini) *Ent. Soc. Amer. Ann.* 38: 458-460. (Very general—habitat in gravel bank.)

1907. Digger wasps of North America and West Indies Belonging to the Sub-family Chlorionini. *U.S. Nat. Mus. Proc.* 31: 291-425. (Excellent—Keys—description of sexes—range, etc.)

Frisch, J. A. 1937. Life History of the Digger Wasp *Ammobia ichneumonea* (L.) *Am. Midl. Nat.* 18: 1043-1062. (Excellent—Comprehensive study of habits and prey. Good bibliography.)

Hamm, A. H. and O. W. Richards. 1930. Biology of British Fossorial Wasps. *Trans. Ent. Soc. Lon.* 78. 95-132.

LaRivers, I. 1944. Summary of the Mormon Cricket (*Anabrus simplex*). *Ent. News* 55: (3)71, (4): 97-102.

Pate, V. S. L. 1938. Studies on the Nyssonine Wasps. *Trans. Ent. Soc. Amer.* 64: 117-190.

Peckham, G. W. and E. G. Peckham. 1905. The Great-Golden Digger (In—Wasps Social and Solitary.) Houghton-Mifflin and Co. Boston. (Very good generalized study of habits.)

Reinhard, E. G. 1929. Ammobia, a Stupid Savant (In—Witchery of the Wasps.) Century Co.

Rau, P. and N. Rau. 1918. The Hunters of Large Orthoptera (In—Wasp Studies Afield.) Princeton Press, Princeton, N.J. (Good account of habits. Bibliography.)

Ristich, S. S. 1948. Prey, parasites, predators and habits of the Great-Golden Digger wasp *Chlorion ichneumoneum* (L.) in New York. Ecology Symposium, Comstock Hall Library, Cornell University.

1950. Further studies of the prey, parasites and habits of the Great-Golden wasp *Chlorion ichneumoneum* (L.) in New York. (Detailed tables and pictures.) Ecology Symposium, Comstock Library, Cornell University.

1950. Biology of the Seed Corn Maggot, *Hylemya Cilicrura* (Rond.) and Preliminary Studies on Its Control. Unpublished Thesis, Cornell University.

Spencer, G. J. 1948. A preliminary list of the Sphecinae of British Columbia. *Ent. Soc. Brit. Colum. Proc.* 44: 10.

Some Micro-organisms Associated with the Weevils *Sitophilus granarius* (L) and *Sitophilus oryza* (L).

I Distribution and Description of the Organisms

By A. J. MUSGRAVE[1] AND J. J. MILLER[2]

Introduction

It has been generally accepted by insect microbiologists and physiologists that many insects harbour beneficial micro-organisms. The contributions of Buchner (1933), Glaser (1946), Jeannel (1949), Steinhaus (1946), Wigglesworth (1950) and Woodward (1949) are relevant. Some experimental evidence has been contributed by Aschner 1935, Blewett and Fraenkel (1944), and Brecher and Wigglesworth (1944). It seems that the micro-organisms may sometimes supply the host with vitamins of the B group. (Blewett and Fraenkel). Many species of insects have special organs, called mycetomes, whose chief function seems to be the housing of micro-organisms. Furthermore it has been suggested that special arrangements exist for the transference of micro-organisms from one generation of insects to the next. (Mansour, 1935; Murray and Tiegs, 1935; and Woodward 1949).

Mansour (1935a) claimed, in the two related species of weevils (*Sitophilus oryza* and *Sitophilus granarius*), that while both species had larval mycetomes, only *S. oryza* had associated micro-organisms. This finding has received some general acceptance (Jeannell, Steinhaus, Wigglesworth). However, in a less-well-known journal, Mansour (1935b) published a reconsidered verdict on the position, and stated that it was only the "Egyptian variety" of *S. granarius* that was free of micro-organisms. This somewhat neglected paper of Mansour's was referred to by Koch (1936) who, in describing the micro-organisms of *Oryzaephilus surinamensis*, discussed the conditions in the two species of *Sitophilus* (Calandra). He accepted the existence of a special race of *S. granarius* having no micro-organisms and pointed out that, in a general account of the stored products pests of Egypt, Zacher recognized several morphological differences between the European and Egyptian type of granary weevil, proposing a separate variety, *Calandra granaria* var. *africana*. This variety is, apparently, more resistant to climatically higher temperatures than the European variety and is widespread throughout the Nile Valley. From this complicated situation one might reasonably suppose that a certain warm-temperature variety of *S. granarius* exists that has no symbiotic micro-organisms and, therefore, that such micro-organisms are not essential to the life of this species.

S. oryza would appear to differ in this respect for it is reported always to have micro-organisms. According to Murray and Tiegs (1935), in *S. oryza* the mycetome in the larva consists of a solid mass of tissue that embraces the junction of fore-gut and mid-gut, forming a structure rather like half a collar. At metamorphosis the mycetome, it seems, breaks up into its constituent cells (mycetocytes), which pass back into the developing adult mid-gut, whence they eventually enter the mid-gut coeca (Fig. 1). Thus there is no mycetome in the adult weevil and micro-organisms are in the mid-gut coeca. But, in addition, at some early stage, the micro-organisms are found in the female reproductive system, where they enter the young eggs, thus passing to succeeding generations of weevils.

Presumably, the condition in *S. granarius* is somewhat similar.

[1]Department of Entomology and Zoology, Ontario Agricultural College.
[2]Department of Botany, McMaster University, Hamilton, Ontario.

In an attempt to clarify our knowledge of this subject, Musgrave and Miller (1951), at first unaware of Mansour's (1935b) second paper, recently devised some experiments in which the antibiotic Terramycin impregnated in wheat grains was fed to the two species of weevils. They found that *S. oryza* was affected adversely much more than was *S. granarius*; and it was suggested that this might perhaps be due to a harmful effect of the Terramycin on the micro-organisms.

Observations

These studies have since been continued by searching for micro-organisms in both species of weevils.* The search was begun in the adult, from which the mid-gut was found to be readily removed by dividing the insect transversely at the junction of the prothorax and the elytra. As technique improved it was found possible easily to remove the female gonads and, less easily, those of the males. Eventually, mycetomes themselves could be removed from the larvae, even from those which were quite small. The dissected organs were crushed and lacerated on slides and examined for micro-organisms as thin, covered smears using the phase contrast microscope.

The following observations were made.

1) Bodies that could reasonably be assumed to be micro-organisms were found in both species of weevils. (Compare, Buchner, 1933).

2) Both species of weevils contained micro-organisms of varying size and similar shape, but those of *S. granarius* seemed to be predominantly of greater length than those of *S. oryza*. Mean length of some typical organisms from *S. granarius* was 10.5*m* with a range of from 3*m* to 24*m*; and in *S. oryza* the mean length of some typical micro-organisms was 2.8*m* with a size range from 1.2*m* to 6.0*m*.

3) In each species of weevil micro-organisms of similar appearance were found in the gut and female gonads of the adults and in the mycetomes of the larvae.

4) The micro-organisms occurred in numbers so great that it seems improbable that they are casual invaders, and their occurrence in the mycetome lends support to this view.

5) Micro-organisms were nearly always positively identified in the female reproductive organs and the larval mycetomes of both species.

6) Micro-organisms were never positively identified in the male reproductive organs of either species.

7) Micro-organisms were found more frequently in the mid-gut samples of *S. oryza* than in those of *S. granarius*: positive observations 31 out of 37 in *oryza*; 16 out of 24 in *granarius*.

The micro-organisms stained with difficulty; and greatest success was achieved by staining overnight in Delafield's haematoxylin. However, the organisms could readily be seen in the living condition and as dried smears, by means of the phase contrast microscope. The technique has great advantages, for the partly lacerated tissue is simply placed on a slide, covered with a coverslip, pressed thin, and then viewed in the living condition by the phase microscope. No fixing or staining is necessary. (See figs. 2, 3, and 4).

The phase microscope reveals the "micro-organisms" as short or long rods with rounded ends. When long they are frequently curled or looped. They seem to be of fairly uniform consistency, but contain commonly one or two opaque granules; or, very occasionally, many small opaque granules. The organisms could sometimes be seen in pairs or in bundles outside the mycetocytes.

*Bred at approximately 27°C.

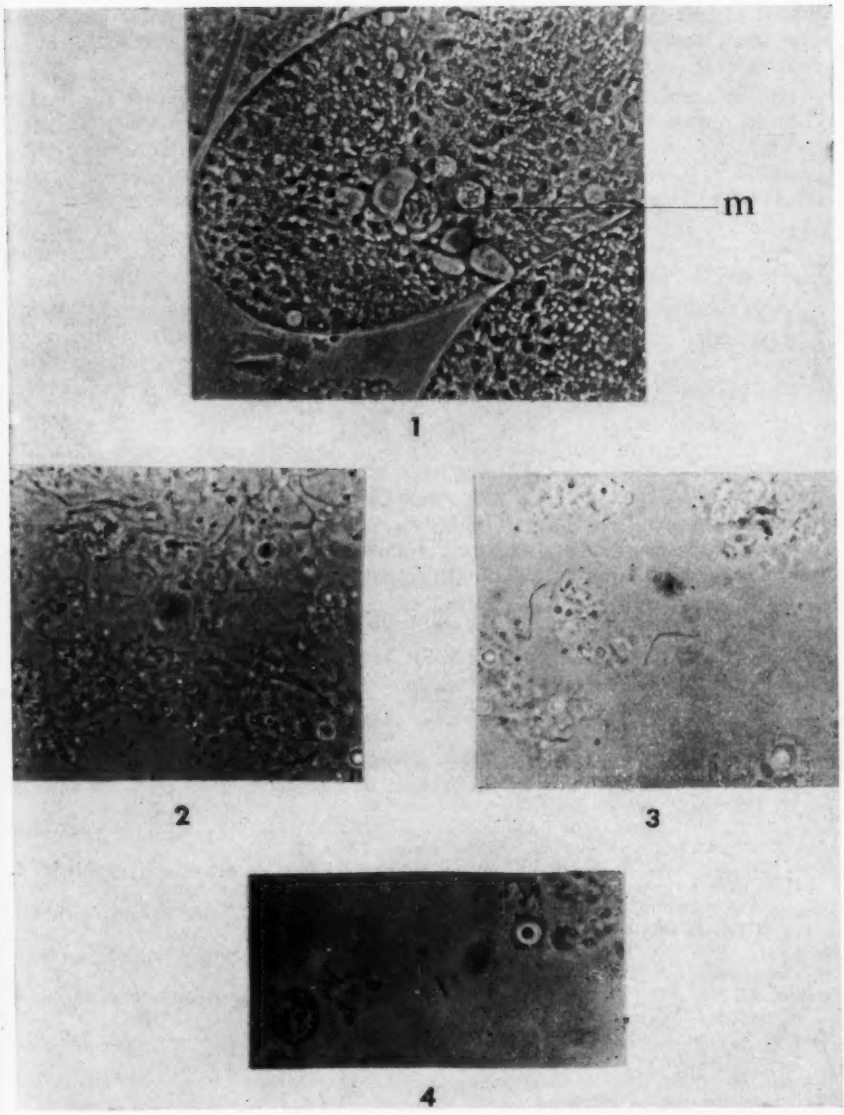


Fig. 1. Parts of three coeca from the mid-gut of *S. oryza*, showing mycetocytes. X approx. 833. Phase: *m*, mycetocyte.
Fig. 2. Micro-organisms in a smear of the ovary of *S. granarius*. Phase X approx. 1700.
Fig. 3. Micro-organisms in a smear of the ovary of *S. granarius*. Phase approx. 1700.
Fig. 4. Micro-organism in a smear of *S. oryza*. Phase X approx. 1700.

When seen inside the mycetocytes they were usually in motion. Sometimes they filled the mycetocytes to the exclusion of their nuclei. The larger organisms commonly found in *S. granarius* appeared to be separate organisms and not to be

formed of several smaller bodies joined together. Occasionally (about twice) very small and characteristically different micro-organisms were seen in *S. granarius*.

It has seemed reasonable to follow tradition and assume that the bodies observed are micro-organisms; and that they are of benefit to the host. (cf. Buchner, Steinhaus, and others). They are quite different in appearance from those discussed recently by Lanham (1952) which occur in some aphids and which were relegated by him to the classification of "cell particulates". The behaviour, shape and distribution of the "micro-organisms" in the weevils are in conformity with their being living, separate entities, in close association with their hosts, and possibly of benefit to them.

The size difference of the organisms may, of course, be due to either genetic or physiologic reasons. Steinhaus (quoting Mansour) referred to the wide variation in size of micro-organisms during the insects' life cycle in three Bostrichid beetles but no explanation was offered. Further work is needed here.

Acknowledgments

The work was done in the Department of Entomology and Zoology, Ontario Agricultural College, (Head, Professor A. W. Baker) and the Department of Botany, McMaster University (Chairman, Professor W. D. MacClement). To them and to the many others who have stimulated the work by their help, advice, and encouragement grateful acknowledgment is gladly extended.

References

Aschner, M. 1934. Studies on the symbiosis of the body louse. I. Elimination of the symbionts by centrifugalisation of the eggs. *Parasitology* 26: 309.

Blewett, M., and G. Fraenkel. 1944. Intracellular symbiosis and vitamin requirements of two insects, *Lasioderma serricorne* and *Sitodrepa panicea*. *Proc. Roy. Soc. London.* (B) 132: 212.

Brecher, G., and V. B. Wigglesworth. 1944. The transmission of *Actinomyces rhodnii* Erikson in *Rhodnius prolixus* and its influence on the growth of the host. *Parasitology* 35: 220.

Buchner, P. 1933. Studien an intrazellularen Symbioten. VII. Die symbiontischen Einrichtungen der Rüsselkäfer. *Z. Morph. Oekol. Tiere* 26: 709.

Glaser, R. W. 1946. Intracellular bacteria of the cockroach in relation to symbiosis. *J. Parasit.* 32: 483.

Jeannell, R. 1949. Ordre des Coléoptères. "Partie Général" in "Traité de Zoologie", Ed. by P. P. Grassé. P. 771. Masson et Cie, Paris, France.

Koch, A. 1936. Symbiosestudien. II. Experimentelle Untersuchungen an *Oryzaephilus surinamensis* L. *Z. Morph. Oekol. Tiere, Berlin,* 32: 139.

Lanham, U. N. 1952. Observations on the supposed intracellular symbiotic micro-organisms of Aphids. *Science* 115: 459.

Mansour, K. 1935b. On the micro-organism free and infected *Calandra granaria*. *Bull. Soc. Ent. Egypte, Cario* 19: 290.

Mansour, K. 1935a. The so-called sybiotic relationship between Coleopterous insects and intracellular micro-organisms. *Quart. J. Micro. Sci.* 77: 225.

Murray, F. V., and O. W. Tiegs. 1935. The metamorphosis of *Calandra oryzae*. *Quart. J. Micro. Sci.* 77: 405.

Musgrave, A. J., and J. J. Miller. 1951. A note on some preliminary observations on the effect of the antibiotic Terramycin on insect symbiotic micro-organisms. *Canad. Ent.* 83: 343.

Steinhaus, E. A. 1946. Insect Microbiology. Comstock Publishing Co. Inc., N.Y., U.S.A.

Wigglesworth, V. B. 1950. The Principles of Insect Physiology. Methuen, London, Eng.

Woodward, T. E. 1949. The internal male reproductive organs in the genus *Nabis* Latreille. (Nabidae: Hemiptera-Heteroptera) *Proc. R. Ent. Soc. London* (A) 24: 111.

Note on *Dichaetoneura leucoptera* Johns. (Diptera, Tachinidae)

By W. R. THOMPSON
Commonwealth Institute of Biological Control

Shortly after the publication of my paper on this species, (*Can. Ent.*, Vol. LXXXV, No. 1) I received a letter from Mr. R. W. Smith, of the Belleville Laboratory, giving some of the results obtained in a study of *leucoptera* in the parsnip webworm, *Depressaria heracleana* L., in 1926. In this study, writes Mr. Smith, "first-stage larvae were found in fifth and sixth instar hosts. Their most frequent location was in the musculature of the rectal region of the hind gut".

In caterpillars of *Archips cerasivorana* preserved for me by Mr. A. Dustan and D. Groves in June of this year, I have been able to verify the statement of Mr. Smith. All the first stage *leucoptera* found were in the hind gut. They have not however, been found in the musculature. Microscopic examination of intestines containing the larva showed clearly that they lie within the circular muscle layer but their exact position was difficult to determine. Sections show that in reality the larva lies between the epithelium of the hind intestine and its chitinous intima, completely enclosed in a pouch lined on the inside by the intima and on the outside by the epithelium (Fig. 1). In this region of the intestine the intima is relatively thick and resistant and the epithelial wall is also stout. This no doubt explains how the larva is able to insert itself between the two layers without tearing the epithelium to pieces. Whether it enters the host caterpillar through the skin or by way of the hind intestine, remains to be determined. At all events it appears that the integumental funnel is produced by the first stage larva, perhaps by forcing the posterior extremity through the intestinal epithelium, the hypodermis and the cuticle. As has already been shown, the opening of the funnel is always on the ventral side of the last segment and is particularly obvious in pupae containing *leucoptera*.

This is the first record of which I know, of a Tachinid larva living in the hind intestine, though *Townsendiellomyia nidicola* Towns. hibernates in the fore

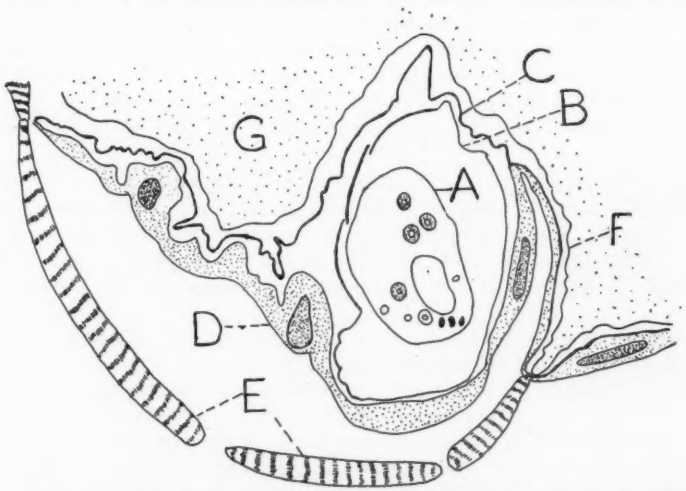


Fig. 1. *Dichaetoneura leucoptera* Johns. Cross section of primary larva in wall of hind intestine of *Archips cerasivorana; A.* body of larva, detached from cuticle; *B*, larval cuticle; *C*, chitinous intima of hind intestine; *D*, epithelium of hind-intestine; *E*, circular muscles of hind intestine; *F*, peritrophic membrane; *G*, contents of hind intestine.

intestine, *Compsilura concinnata* Meig., and *Dexodes* spp. live in the mid-intestine, where (as will be shown in a later paper) *Eusisyropa blanda* O.S. and a species allied to *Patelloa pachypyga* A. & W., also pass at least the early part of the larval cycle.

Book Notices

ENTOMOLOGICAL PHOTOGRAPHY IN PRACTICE, by E. F. Linssen, F.Z.S., F.R.E.S., F.R.P.S. (former editor of the Entomological Monthly) 112 pp. 54 figs. The Fountain Press, London, England, price 32s. 6d.

This small book by the former editor of the Entomological Monthly who is also an experienced photographer is designed as an introduction to the art of photographing insects. It contains a good deal of useful general information on the subject. However to experienced photographers the technical information will appear somewhat inadequate, while on the other hand an unnecessary amount of space is devoted to facts well known to entomologists apparently in the belief that the reader of the book will welcome suggestions as to what insects he should photograph.

CYTOCHEMISTRY, A CRITICAL APPROACH, by J. F. Danielli, Professor of Zoology, King's College, London, W.C. 2. 139 pp. 12 plates, 8 text figures. John Wiley & Sons, Inc., New York, Chapman & Hall, Limited, London, England. Price $4.00.

This book deals with advanced cytochemical research in certain special fields. It is not, says the author, intended in any way as a text book but is very largely a record of experiments which he has carried out himself or which have been carried out by other research workers with whom he has been closely associated. After an introductory chapter the author deals with fixation procedures, studies on alkaline phosphatases, the critical study of the cytochemistry of aldehydes, the cytochemistry of proteins and nucleic acids, quantitative studies in cytochemistry and the future outlook in this subject.

A MANUAL OF ENTOMOLOGICAL TECHNIQUES, by Alvah Peterson, Ohio State University, Seventh Edition, Lithoprinted in U.S.A. by Edwards Brothers, Inc., Ann Arbor, Michigan; pp. v plus 367, 182 plates, 17 tables.

We welcome the appearance of a new edition of Professor Alvah Peterson's valuable "Manual of Entomological Techniques". This now contains an enormous mass of youthful information accompanied by simple but clear figures in regard to almost all aspects of entomological work both in the laboratory and in the field.

The richest sections of Professor Peterson's book concern rearing cages, collecting and sampling equipment, traps, apparatus for measuring environmental factors, utilizing measured intensities in experimental work and evaluating their effects. Most workers will find descriptions and figures of apparatus suitable for their special problems or at least designs they can readily modify for their special needs.

In regard to the various aspects of microscopic work, including the preservation of material for dissection, mounting, staining and so forth, the treatment seems somewhat inadequate. This is no doubt partly due to the fact that many special works on microscopic technique exist but as Professor Peterson complains it is also the fault of the many entomologists who neglect to give detailed accounts of their special methods. Nevertheless though the chapters on microscopical technique are rather short they all contain valuable suggestions.

Presumably the book can be obtained from Professor Peterson in Ohio State University but the price is nowhere mentioned. W. R. THOMPSON

THE RUNGE PRESS LIMITED, OTTAWA
Mailed: Wednesday, October 21st, 1953